

**Missouri Department of Natural Resources
Water Pollution Control Program**

Total Maximum Daily Loads (TMDLs)

for

**Jacks Fork River
Shannon County, Missouri**

**Completed: December 30, 2003
Approved: January 21, 2004**

**Total Maximum Daily Load (TMDL)
For Jacks Fork River
Pollutant: Fecal Coliform**

Name: Jacks Fork River

Location: Near Eminence in Shannon County, Missouri

Hydrologic Unit Code (HUC): 11010008-050

Water Body Identification Number (WBID): 2681

Missouri Stream Class: P¹

Pollutant: Fecal Coliform

Pollutant Source: Organic wastes

Beneficial Uses:

- Livestock and Wildlife Watering
- Protection of Aquatic Life and Human Health associated with Fish Consumption
- Cool Water Fishery
- Whole Body Contact Recreation (Swimming)
- Boating and Canoeing

Standards that apply:

- Missouri's Water Quality Standards (WQS) at 10 CSR 20-7.031(4)(C) state that the fecal coliform count shall not exceed 200 bacterial colonies per 100 milliliters of water during the recreational season (April 1-October 31) in waters designated for whole-body contact recreation.
- Anti-degradation Policy – The Jacks Fork is an Outstanding Natural Resource Water, which is classified in the WQS under “Tier Three Waters” (10 CSR 20-7.031(2)(C)). For these waters, no degradation of water quality is allowed. That means that whatever fecal coliform occurs naturally in the river is the “natural background” and it then becomes the standard for the Jacks Fork.

Size of Impaired Segment: 7.0 miles (changed from 5.0 miles on the 1998 303(d) list)



¹ Streams that maintain permanent flow even in drought periods. See Missouri Water Quality Standards (WQS) 10 Code of State Regulations 20-7.031(1)(F). The WQS can be found at the following uniform resource locator (URL): http://www.dnr.mo.gov/wpscd/wpcp/wqstandards/wq_standard_hm.htm

Location of Impaired Segment: From the mouth in S ½ Section 9, T29N, R3W (downstream) to E ½ Section 26, T29N, R4W upstream. The upstream end of the seven miles proposed is the line between Sections 25 and 26, T29N, R4W. This is approximately 0.8 miles downstream of the Highway 19 bridge.

TMDL Priority Ranking: High

1. BACKGROUND AND WATER QUALITY PROBLEMS

Area History:

Shannon County was formed in January 29, 1841, from Ripley and Washington counties. These three counties do not share any border today. The county was named for George Shannon, the youngest member of the Lewis and Clark Expedition, who was 18 years old when he joined the expedition². He traveled with the expedition from beginning to end and was considered a solid worker. He did, however, get lost a few times. William Clark named a tributary to the Yellowstone River in Montana in honor of this young man³. The tributary name remains Shannon Creek to this day. Later in life, Shannon became a lawyer and served as U. S. Senator from Missouri⁴.

Land Use and Soils⁵:

The Jacks Fork River is an Outstanding National Resource Water, as are parts of the Current River and Eleven Point River. The North Prong and South Prong of the Jacks Fork join to form it. These streams join northwest of Mountain View, Missouri. From this point, the Jacks Fork River flows in an easterly direction for 49.1 miles before joining the Current River northeast of Eminence, Missouri. It covers over 280,000 acres (about 440 square miles). The river has an average gradient of 7.1 feet/mile.

The watershed is mainly forested. Land use data indicates estimated combined forest/woodland cover within the Jacks Fork watershed at 76 percent, while grassland/cropland comprises 23 percent of the total land cover. Two towns in the watershed, Eminence and Mountain View, have populations of over 500 persons. Within the Jacks Fork Watershed, approximately 19 percent or 55,330 acres are in public ownership. The Missouri Department of Conservation owns approximately 73 percent or 40,490 acres of that total. 1993 data (30 meter resolution) obtained from Thematic Mapper imagery was used to calculate land use statistics for the watershed. Appendix A contains a land use map and a table showing the total area in acres for each land use category.

Caves, springs, losing streams and sinkholes are common in the watershed due to the karst nature of its topography. United States Geological Survey (USGS) topographical maps show there are 22 springs within the watershed. Surveys performed within National Park Service boundaries, however, indicate there are many more. Alley Spring is the largest spring within the watershed with an average discharge of 125 cubic feet per second, or 81 million gallons per day.

² Shannon County, Missouri, <http://www.rootsweb.com/~moshanno/>

³ Private George Shannon, <http://www.pbs.org/lewisandclark/inside/gshan.html>

⁴ <http://lewisandclarktrail.com/elearningshannon.htm>

⁵ Missouri Department of Conservation, "*Missouri's Rivers and Their Watersheds*" found on the Internet at: <http://www.conservation.state.mo.us/fish/watershed/index.htm>

The Jacks Fork Watershed occurs within the Ozarks Soil Region. Allgood and Persinger (1979) describe the Ozark Soils Region as “cherty limestone ridges that break sharply to steep side slopes of narrow valleys. Loess occurs in a thin mantle or is absent. Soils formed in the residuum from cherty limestone or dolomite range from deep to shallow and contain a high percentage of chert in most places. Some of the soils formed in a thin mantle of loess are on the ridges and have fragipans, which restrict root penetration. Soil mostly formed under forest vegetation with native, mid-tall and tall grasses common in open or glade areas.”

The following is a list of soil associations found in the Jacks Fork Watershed:

- Captina-Clarksville-Doniphan: Nearly level to very steep, moderately well drained to excessively drained loamy upland soils that have fragipans or soils that are cherty throughout.
- Captina-Macedonia-Doniphan-Poynor: Nearly level to very steep well drained and moderately well drained, loamy upland soils that have fragipans or soils that are cherty throughout.
- Hobson-Coulstone-Clarksville: Gently sloping to very steep, moderately well drained to somewhat excessively drained, loamy soils with fragipans or soils that are cherty throughout.
- Lebanon-Hobson-Clarksville: Gently sloping to very steep, moderately well drained to somewhat excessively drained, loamy and clayey soils with fragipans or soils that are cherty throughout.
- Wilderness-Clarksville-Coulstone: Gently sloping to very steep, moderately well drained to excessively drained, loamy upland soils that have cherty subsoils or fragipans.

Land use in the watershed has changed dramatically in the last 150 years. There was a timber boom in the Ozarks in the late 1800s, followed by row cropping. Corn production peaked between 1899 and 1920. As corn production decreased due to thin soils, livestock farming increased. Valley bottoms were being settled, cleared, and farmed. Removal of riparian vegetation resulted in increased erosion in the stream valley. The logging and farming practices used early in the 20th Century resulted in major erosion from the uplands and added a large gravel load to the Jacks Fork. In a study of 90 years in the Ozarks, Jacobson and Primm (1994) suggest that “land use changes have disturbed parts of the hydrologic or sediment budgets or both.” They also state that this “disturbance has been characterized by accelerated aggradation of gravel, especially in formerly deep pools, accelerated channel migration and avulsion [*loss of large blocks of soil to stream erosion*], and growth of gravel point bars.”

Defining the Problem:

The Jacks Fork River is a major recreation resource used for canoeing, fishing, swimming and trail riding. A five-mile stretch of the river, immediately upstream of the confluence with the Current River, was placed on the 1998 303(d) list of impaired waters for excess fecal coliform bacteria. This violates the Missouri standard for Whole Body Contact Recreation of 200 colonies per 100 milliliters (col/100 mL) of fecal coliform. Fecal coliform are non-pathogenic (do not cause human illness) bacteria that act as indicators of the risk of waterborne disease. They are found in the intestines and are used to detect fecal contamination of the water by humans or other warm-blooded animals. The Department of Natural Resources and the National Park Service (NPS) collected bacteria samples prior to 1998. This data indicated that fecal coliform bacteria levels were elevated at some locations relative to the upstream segments of the river and the higher bacteria counts were not attributed to natural causes. Since March 1999, the U. S. Geological Survey (USGS) has conducted bacterial tests at sites in and around the impaired segment of the Jacks Fork. Analysis of

the bacteria source tracking information⁶ indicates that horses, sewage and cattle were possible sources of the bacteria. It is assumed the source of the sewage is from on-site septic systems, since data indicates the Eminence wastewater treatment facility (WWTF) is not a contributing source. The length of the impaired segment was changed to seven miles on the Missouri 2002 303(d) list due to recent data indicating a fecal coliform problem exists over a broader area.

Source Assessment:

This section examines all known fecal coliform sources in the watershed.

Point Sources

Point sources have the potential to increase the amount of bacteria in a river during low-flow conditions in late summer and early fall. There are six facilities in the Jacks Fork River watershed with Missouri State Operating Permits.⁷ Table 1 lists these point sources and Figure 1 is a map showing their relative location within the watershed.

Table 1. State Permitted Facilities in the Jacks Fork River Watershed

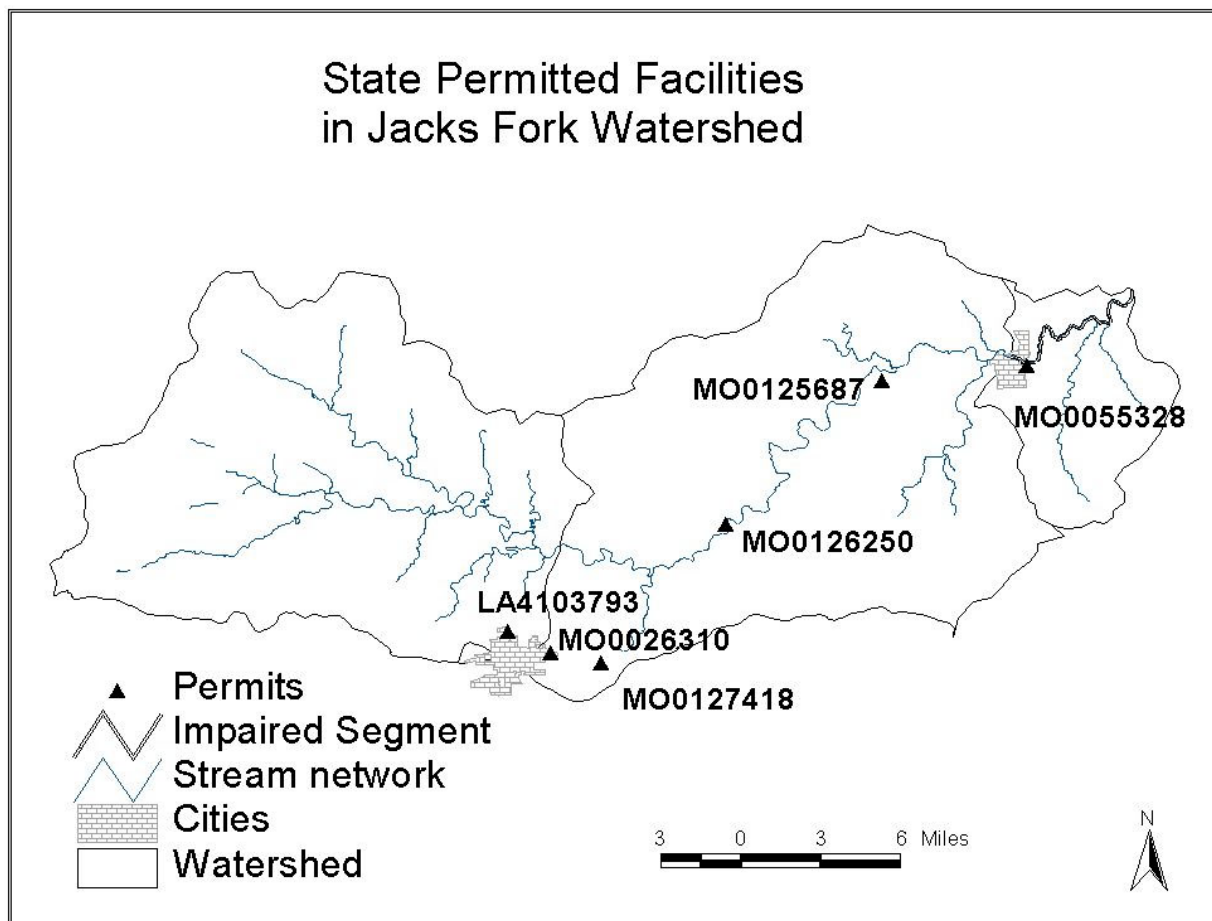
Facility ID	Facility Name	City	County	Receiving Stream
LA4103793	Letter of Approval*	Mountain View	Howell	Panther Hollow
MO0026310	Mountain View WWTP	Mountain View	Howell	Jam Up Creek
MO0055328	Eminence WWTF	Eminence	Shannon	Jacks Fork
MO0125687	US NPS Alley Spring WWTP	Eminence	Shannon	Jacks Fork
MO0126250	Bunker Hill Ranch Resort	Mountain View	Howell	Unnamed Trib to Jacks Fork
MO0127418	Liberty High School WWTF	Montier	Shannon	Jam Up Creek

*This Letter of Approval is for a poultry operation of 29,750 laying hens

⁶ Bacterial source tracking is using DNA to determine what kind of animal (including humans) the bacteria comes from. Ribotyping was the type of source tracking used by USGS from November 1999 through December 2000. Since August 2001 the USGS has used repetitive Polymerase Chain Reaction (rep-PCR).

⁷ The state permitting system is Missouri's program for administering the National Pollution Discharge Elimination System (NPDES) program.

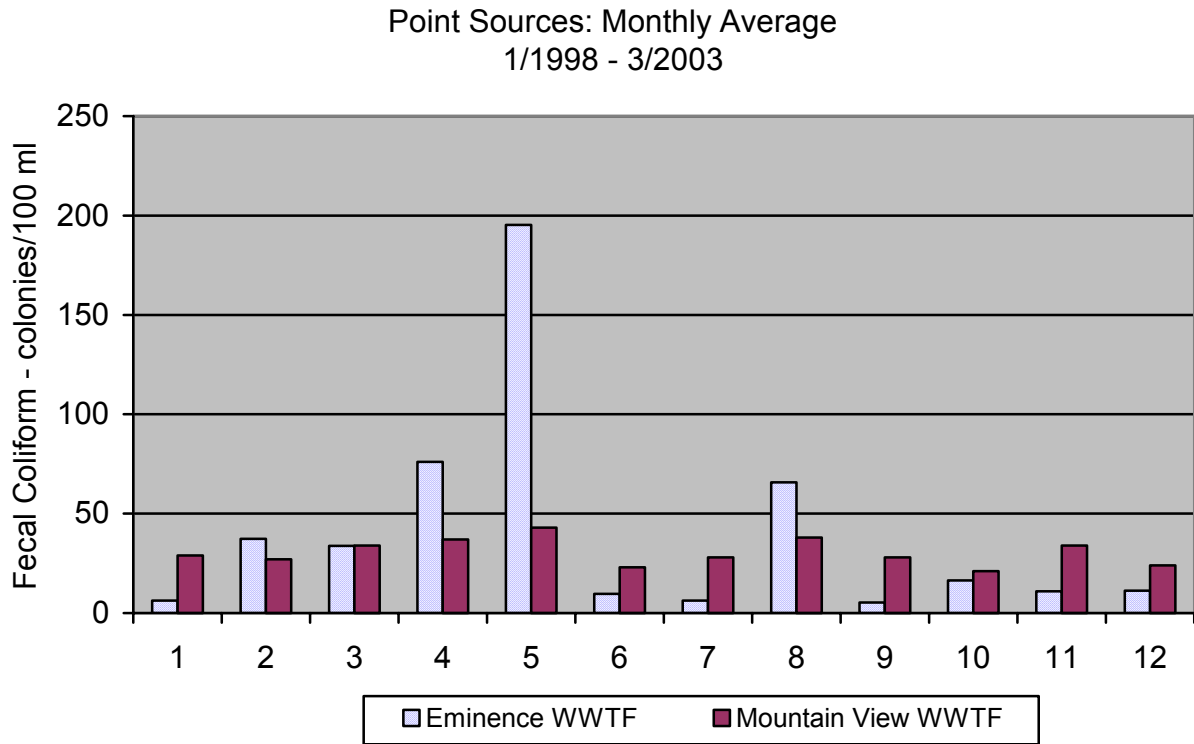
Figure 1. Location Map of Permitted Point Sources



Of these six facilities, four are no-discharge systems. A no-discharge permit requires the facility to be designed, constructed and operated to have no discharge, unless caused by a catastrophic storm (24-hour duration exceeding the 25-year recurrence frequency). The only discharging point sources in the watershed are the Eminence and Mountain View facilities. These towns are the two population centers in the watershed, Eminence with a population of 548 and Mountain View with a population of 2,315. It should be noted that only a part of the Mountain View city boundaries are in Jacks Fork watershed. Both towns' wastewater treatment plants, however, discharge into tributaries of the Jacks Fork River and both have disinfection required in their permits. Since disinfection is required, these permits have fecal coliform limits. Monthly Discharge Monitoring Report (DMR) data from 1/1998 to 3/2003 have been analyzed. Mountain View's average monthly bacteria count was highest in May (43 col/100 mL) and lowest in October (21) during the recreational season. Eminence Wastewater Treatment Facility (WWTF) had the highest monthly average⁸ in May (195) and the lowest in September (5). See Figure 2. Figure 3 shows the yearly average (of all individual data points) fecal coliform outputs from the Eminence and Mountain View WWTF over a five-year period.

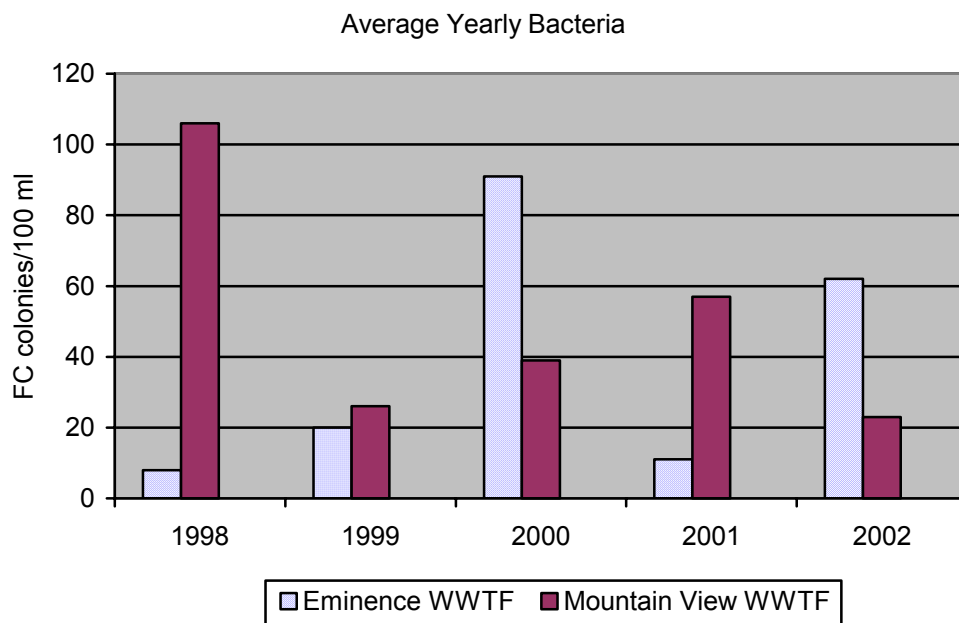
⁸ The term "monthly average" is language used in a permit. The number of samples per month is based on the size of the facility (10 CSR 20-7.015 (3)(C)).

Figure 2. Monthly average fecal coliform in the discharge of Eminence and Mountain View Wastewater Treatment Facilities



Note: Numbers 1-12 on the X-axis correspond to the 12 months of the year starting with January.

Figure 3. Yearly average fecal coliform in the discharge of Eminence and Mountain View Wastewater Treatment Facilities



Nonpoint Sources

There are several potential nonpoint sources of fecal coliform bacteria in the Jacks Fork watershed. These sources include:

- **Failing or Inadequate On-Site Septic Systems**

On-site sewage treatment systems have the potential to deliver bacteria loads to surface water due to malfunction, failure, or direct pipe discharge. When properly operated and maintained, septic systems can effectively treat wastewater and prevent surface and ground water contamination. It is estimated that there are approximately 4,000 on-site septic systems in the watershed. It is also estimated that half of these are failing (communication with Ron Gaston, Texas and Shannon County Public Health Office). During the recreation season, particularly on weekends, the watershed population can quadruple and the potential for fecal coliform loading increases dramatically. In addition, systems (often called “straight pipes”) exist in the watershed that continue to discharge wastewater directly to surface water by design, without any form of treatment.

- **Wildlife**

Wildlife estimates include deer and other potential fecal coliform producers. It is estimated that there are about 20 deer per square mile in the watershed (communication with Loni Hensen, Deer Biologist, Missouri Department of Conservation). The assumption is that wildlife, and the manure they produce, is evenly distributed over forested and agricultural land. Fecal coliform from wildlife cannot easily be distinguished from contributions from other warm-blooded animals. In-stream bacteria samples reflect all sources, including inputs from wildlife, domestic animals and humans.

- Land application of animal manure and poultry litter

There are no operations in the watershed with a State Operating Permit to apply animal manure or poultry litter. Some farmers, however, do spread animal manure on their hay fields.

- Grazing animals

Grazing animals deposit manure on pastureland where it may runoff during storm events and deliver bacteria to the water. Many cattle producers, primarily located in the upper reaches of the river, are already implementing best management practices. In some areas of the watershed, however, cattle do have unlimited access to the river and its tributaries. This can result in bacteria inputs when cattle defecate directly into the water.

- Urban development

Urban areas include barren and built-up-land. Fecal coliform loadings from this category occur mainly during rain events in the form of stormwater runoff. As this is a sparsely populated watershed with only two small communities (Mountain View and Eminence), urban runoff is not considered to be a significant contributor to the impairment.

- Trail rides

There are at least three trail ride facilities in the Jacks Fork watershed. The largest facility has 2,990 horse stalls available on their property. This facility hosts six to eight trail rides each year during the recreation season. The rides last from four to seven days and attract many out-of-state participants. It has been reported that trail rides may include as many as 2,800 riders and their horses. The proximity of this trail ride facility to the river represents a potential source of organic runoff and associated bacteria during storm events. In addition, horse trails cross the main stem of the river below the City of Eminence. This creates the potential for direct deposits of manure while the horses are in the river. Also, when horses, canoeists, cattle or wild animals walk in the river, they stir up sediment. Bacteria tied up in the sediments can be released whenever the streambed sediment is disturbed.

- Recreational Use

The National Park Service (NPS) is responsible for the management of the Ozark National Scenic Riverways (ONSR). The ONSR includes the Current and Jacks Fork rivers. The Jacks Fork is one of the most popular float streams in Missouri. The NPS reported 241,997 Total Recreation Visits to the Jacks Fork River in 1999, with most of them (212,644) occurring during the recreational season, from April 1 to Oct. 31. The number of vessels permitted by the NPS to concessionaires on the Jacks Fork included 700 canoes, 21 kayaks, and 250 tubes. These figures do not include privately owned vessels that can be on the river on any given day. This translates into thousands of canoeists floating the Jacks Fork during the recreational season and creates the potential for human waste to be deposited in the riparian corridor. Public toilet facilities are available adjacent to the river in several locations. This does not, however, ensure the facilities are adequately utilized. There are also difficulties in providing toilet facilities close enough to the river to offer easy access for canoeists and yet not be vulnerable to flooding. Road access for maintenance is another issue that limits the number of toilet facilities along the river.

2. DESCRIPTION OF THE APPLICABLE WATER QUALITY STANDARDS AND NUMERIC WATER QUALITY TARGETS

Designated Uses:

The designated uses of Jacks Fork River, WBID 2681, are:

- Livestock and Wildlife Watering
- Protection of Aquatic Life and Human Health [associated with] Fish Consumption
- Cool Water Fishery
- Whole Body Contact Recreation (Swimming)
- Boating and Canoeing

The use that is impaired is Whole Body Contact Recreation (Swimming). The stream classifications and designated uses may be found at 10 CSR 20-7.031 (1)(C) and Table G.

Anti-degradation Policy:

Missouri's Water Quality Standards include the Environmental Protection Agency (EPA) "three-tiered" approach to anti-degradation, and may be found at 10 CSR 20-7.031(2).

Tier I defines baseline conditions for all waters and requires that existing beneficial uses are protected. TMDLs would normally be based on this tier, assuring that numeric criteria (such as dissolved oxygen and ammonia) are met to protect uses.

Tier II requires that no degradation of high-quality waters occur unless limited lowering of quality is shown to be necessary for "economic and social development." A clear implementation policy for this tier has not been developed, although if sufficient data on high-quality waters are available, TMDLs could be based on maintaining existing conditions, rather than the minimal Tier I criteria.

Tier III (the most stringent tier) applies to waters designated in the water quality standards as outstanding state and national resource waters; Tier III requires that no degradation under any conditions occurs. Management may prohibit discharge or certain polluting activities. TMDLs would need to assure no measurable increase in pollutant loading.

The Jacks Fork River is designated an Outstanding National Resource Water. This TMDL will assure that there will be no measurable increases in pollutant loading, which conforms to Missouri's Tier III anti-degradation policy. To comply with this policy, the endpoint for the fecal coliform TMDL will be based on the natural background condition rather than on the water quality standard cited below.

Specific Criteria:

Missouri's Water Quality Standards at 10 (CSR) 20-7.031(4)(C) state:

"Protections of whole-body-contact recreation is limited to classified waters designated for that use. For periods when the stream or lake is not affected by stormwater runoff, the fecal coliform count shall not exceed two hundred colonies per one hundred milliliters (200/100mL) during the recreational season in waters designated for whole-body-contact recreation or at any time in losing streams. The recreational season is from April 1 to October 31."

It should be noted that the stormwater runoff exemption mentioned in the rule above does not specifically correspond to any particular flow probability or frequency of occurrence, and will not apply for this TMDL since this water body is protected under Tier III of Missouri's Anti-degradation policy as described above.

Selection of a TMDL Endpoint (Water Quality Target) and Critical Condition:

Endpoints or targets are used to evaluate the attainment of acceptable water quality conditions. The instream numeric endpoints represent the water quality goals that are to be realized by implementing the load and wasteload reductions specified in the TMDL.

Jacks Fork River is classified as an Outstanding National Resource Water (ONRW). According to Missouri water quality standards, outstanding waters must be protected from any water quality degradation. That is, no increase in net loading of any pollutant is allowed in these waters. To preserve the natural conditions in the Jacks Fork and to comply with the Antidegradation policy, the fecal coliform bacteria target will be equal to the natural background or the bacteria levels observed in the unimpaired portion of the watershed. To determine this background condition, the watershed was divided into three areas, the upper, middle, and lower sub-basins (Figure 1 in Appendix C). The Upper Jacks Fork extends from the headwaters to Hwy 17 Bridge near Mountain View. The Middle Jacks Fork starts at the Hwy 17 Bridge and ends near Eminence at Hwy 19 Bridge. The Lower Jacks Fork covers the remainder of the watershed ending at the mouth. The impaired stream segment is in the Lower sub-watershed.

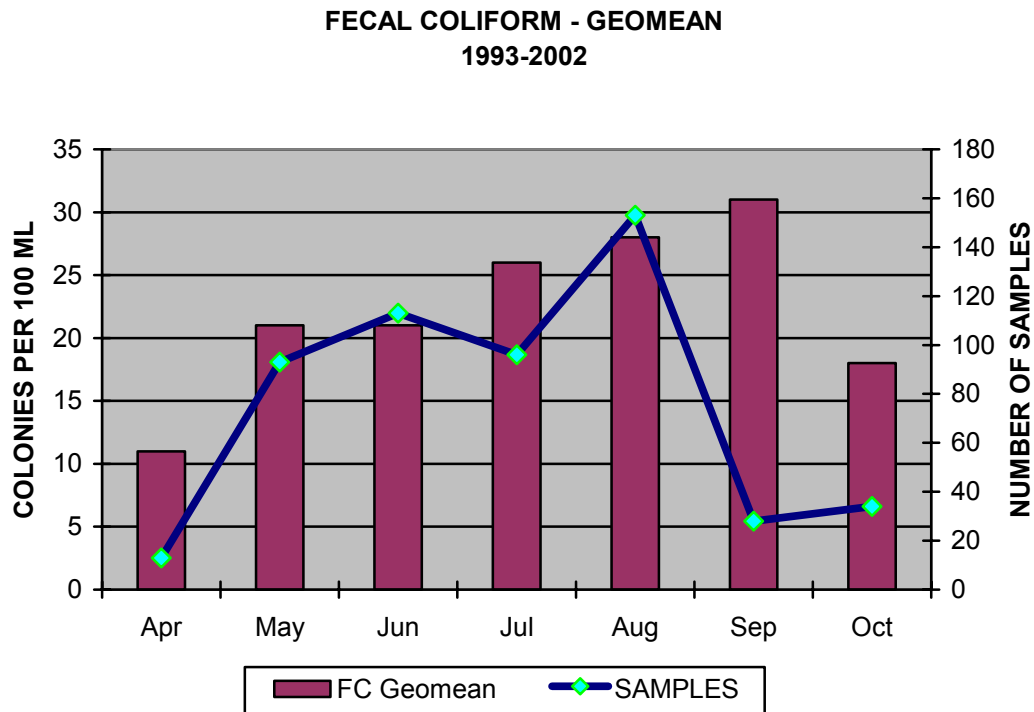
All non-zero bacteria data collected in the Upper and Middle Jacks' sub-watersheds (target area) were combined. The resulting data set contained 580 fecal coliform records. A flow duration analysis using USGS gage station data from the Hwy 19 Bridge station identified extreme high flow ranges. For the purpose of this document, extreme flow occurrences were considered to have a probability of less than 0.05. These extreme high flows were excluded from the base data used to derive the bacteria target.

Analyzing the flow regime at the Highway 19 bridge over an 80-year period, it was identified that a discharge of $1,380 \text{ ft}^3/\text{s}$ has a probability of 0.05. Therefore, any fecal coliform data collected at this site during any flow equal to or greater than $1380 \text{ ft}^3/\text{s}$, or any data collected in the target area on that same day was not included. The assumption made is that any extreme flow at the Hwy 19 Bridge is also an extreme flow throughout the watershed. Of the 580 non-zero fecal coliform samples, 10 were collected during extreme high flows. Of the remaining 570 samples, 530 were collected during the recreational season that extends from April 1 to October 31. The data covered a period of ten years (1993 to 2002) and may be found in Appendix D. Note that Table 3 in Appendix D includes the raw data only. The "missing" flow data for each fecal coliform value were estimated from other known gauging stations in the watershed. The calculation of the missing flows was based on the size of the drainage areas and verified by some instantaneous discharge measurements. These data are available in the administrative file for the Jacks Fork.

Because fecal coliform data can be highly variable and there are uncertainties inherent in sample collection and analysis, Missouri chooses to use an average of bacteria colonies to determine the endpoint for the Jacks Fork TMDL. Calculating a standard arithmetic average can skew the result, due to the influence of infrequent, high bacteria concentrations that are often considered to be outliers. A geometric average, also referred to as a geomean, provides a better indication of what is

actually occurring in the water. It lessens the impact of infrequent, high bacteria counts on the final result. Therefore, a geometric mean will be used in determining the endpoint (See Appendix B for geometric mean calculation). Figure 4 shows yearly geometric mean fecal coliform counts and the corresponding number of samples collected in the target area.

Figure 4. Yearly Geometric Means for Fecal Coliform in the Jacks Fork River



Four organizations have collected fecal coliform and flow data in the Jacks Fork watershed (Appendix D, Table 2). There are 34 sampling sites located either on the mainstem or its tributaries (Appendix C, Table 1). These data were collected over a ten-year period from 1993- 2002. The geometric mean of all samples collected in the upper or middle sub-basins was calculated to be 21col/100 mL during the recreational season. The monthly geometric mean calculated across the period of record showed that September has the highest count (31) and April has the lowest (11). The average of the monthly geometric means during the recreational period is 22 col/100 mL, with a standard deviation of seven and a 75th confidence interval of three. The upper 75th percentile corresponds to 25 col/100 mL. It is therefore reasonable to set the endpoint as follows:

Ambient Fecal Coliform colonies shall not exceed a 30-day geometric mean of 25 col/100 mL. Nor shall any single sample exceed 200 col/100 mL, which is the statewide standard. To calculate the geometric mean the analysis must include at least four samples, equally spaced, within a 30-day time period.

3. CALCULATION OF LOAD CAPACITY

Establishing the relationship between the instream water quality target and the contribution from the pollutant source (source loading) is a critical component of TMDL development. This relationship

provides a method to evaluate management alternatives that will help achieve the desired source load reductions. Computer models are used to develop source load contributions. Relevant monitoring data should support the linkage between flow and loading conditions to waterbody responses.

Model:

A Load Duration Curve analysis and Excel Spreadsheet model were used to calculate the TMDL target. A load duration curve represents the TMDL at every stream flow associated with its probability of occurrence. The curve is the product of the endpoint concentration (col/100 mL), the flow in cubic feet per second (ft³/s), and a conversion factor (Appendix B). It looks like this:

$$\text{Load (colonies/day)} = [\text{Concentration (col/100 mL)}] \times [\text{Flow (ft}^3/\text{s)}] \times [(\text{Conversion Factor})]$$

As previously described, the Jacks Fork watershed was divided into three sub-watersheds. Each of the upper sub-watersheds has one outlet that either coincides with or is near a gauging station. The most downstream outlet (the mouth of the Jacks Fork where it joins the Current River) had no gauging station. The Eminence station was used to estimate daily flows at the mouth. The estimate was based on the relative size of the drainage areas and a few instantaneous flow measurements. For the purposes of this TMDL, the entire watershed was evaluated at the mouth of the Jacks Fork River. The long-term average flow at the mouth is 521 ft³/s. Load duration curves, however, were developed for the Upper and Middle Jacks sub-watersheds to compare the existing load with the target load at their respective outlets. The resulting load duration curves for each sub-watershed are found in Appendix E.

Load Capacity:

Load capacity (LC) is defined as the greatest amount of a pollutant a waterbody can receive without being in violation of Missouri's Water Quality Standards. This total load is then divided among a Waste Load Allocation (WLA) for point sources and a Load Allocation (LA) for nonpoint sources and a margin of safety (MOS). An allowance for an implicit MOS is used to provide a conservative estimate of the acceptable load. This is necessary because of the high number of variables that exist when evaluating a riverine ecosystem. Critical conditions are also a factor when calculating the load capacity.

Using the long-term average flow at the mouth of the Jacks Fork (521 ft³/s) to fill in the above equation, the load capacity is calculated to be:

$$\text{LC (load)} = (25 \text{ col/100 mL})(521 \text{ ft}^3/\text{s})(24465755.45) = \mathbf{3.19E+11 \text{ colonies/day}}$$

In the calculation of this load, a very large number is obtained. To express large numbers, "E + x" is used in scientific notation, where x represents any given number. E+12 indicates that the decimal place has been moved 12 places to the left and is equal to one trillion (1 + 12 zeros). The result of this calculation is 3.19E+11 colonies/day, which is scientific notation for the number 318,688,402,292 colonies/day. This load calculation is based on the long-term average flow and is for illustration purposes only. The actual load will be a continuum over the range of all possible stream flows.

4. WASTE LOAD ALLOCATION (POINT SOURCE LOADS)

The Waste Load Allocation (WLA) is that portion of a receiving stream's load capacity that is allocated to existing or future point source discharges. The critical conditions for point source dominated systems are generally associated with periods of low flow and, consequently, low dilution potential. There are six facilities in the Jacks Fork River watershed, which have Missouri State Operating Permits (See Table 1, page 4). Four of these are no-discharge permits. Because these facilities must comply with their no-discharge permit requirements, releases from a properly designed, operated and maintained facility should be extremely rare. **Therefore the WLA for these five facilities is set to zero colonies per day fecal coliform.**

The other two facilities, Eminence and Mountain View, have fecal coliform limits. They are located in the Middle sub-watershed, and consequently are not part of the load duration curve for the Upper sub-watershed. The combined daily load for these two facilities is calculated from their discharge monitoring report (DMR) data from the last five years. The flows are averaged from the maximum actual flow.

The equation used to calculate the WLA is as follows:

$$WLA = \{[(Flow) (Average Number of col/100 mL)^9 \text{ for Mountain View WWTP}] + [(Flow) (Average Number of col/100 mL) \text{ for Eminence WWTP}]\} \times (Conversion Factor).$$

$$WLA = [(0.56 \text{ ft}^3/s)(39 \text{ col} / 100mL) + (0.5 \text{ ft}^3/s)(46 \text{ col}/100 \text{ mL})] \times (24465755.45) = 1.10E+9 \text{ colonies per day.}$$

This WLA is theoretically constant throughout the year. As noted earlier in this TMDL, both the Eminence and Mountain View wastewater treatment facilities have over the last few years disinfected their wastewater and maintained relatively low bacteria counts in their effluents. Since Jacks Fork is a Tier III Outstanding Resource Water, continued maintenance of these high quality effluent discharges is assumed in this TMDL.

5. LOAD ALLOCATION (NONPOINT SOURCE LOAD)

The load allocation (LA) is that portion of a pollutant loading, which excludes permitted point sources and is the difference between the TMDL, the waste load allocation, and the MOS. Since the Margin of Safety (MOS) is implicit (not numeric) it is not included in this calculation.

The following equation, therefore, expresses the TMDL calculation:

$$TMDL \text{ or LC (Load Capacity)} = WLA + LA$$

Solving the equation for LA:

$$Load Allocation (LA) = LC - WLA$$

So the Load Allocation becomes:

$$LA = 3.19E+11 - 1.10E+9 = 3.18E+11 \text{ colonies per day.}$$

⁹ For each facility, the monthly average over five years of DMR data was used.

The derivation of the TMDL endpoint, or target, was discussed in section 2.1 and was not to exceed a 30-day geometric mean of 25 col/100 mL. Nor was any single sample to exceed 200 col/100 mL, which is the statewide standard. The geometric mean must include at least four samples equally spaced within a 30-day time period.

6. MARGIN OF SAFETY (MOS)

A margin of safety (MOS) is developed due to uncertainties in scientific and technical understanding of water quality in natural systems. The MOS is intended to account for such uncertainties in a conservative manner. Based on EPA guidance, the MOS can be achieved through one of two approaches:

- (1) Explicit - Reserve a numeric portion of the loading capacity as a separate term in the TMDL.
- (2) Implicit - Incorporate the MOS as part of the design conditions for the waste load allocation and the load allocation calculations (or conservative assumptions in the analysis).

In this TMDL the MOS is implicit, based upon the conservative interpretation of data and the assumption that no in-stream decomposition (die-off) of bacteria will occur.

7. SEASONAL VARIATION

Jacks Fork River is designated for whole body contact recreation during the period from April 1 to October 31. During this season, human activities in and around the stream intensify. The TMDL addresses seasonal variation by associating a daily load to every flow. Within the recreation season, the critical season extends from June to October. This is when the flow is generally at its lowest and the stream use is at its peak. If the standards are met within this critical period, then they are sure to be met throughout the whole year. Outside of the recreation season, the watershed will get the same protection as within it because the fecal coliform criteria of 25 col/100mL will be applied year round.

8. MONITORING PLANS UNDER THE PHASED APPROACH

Monitoring the waterbody is an important part of any water quality improvement project. Monitoring reveals the problem and then defines the scope and extent of it. After various management practices are in place, monitoring shows whether water quality has improved or is meeting state standards. Stream monitoring of the Jacks Fork River should satisfy the condition of the endpoint, which calls for a geometric mean of at least four samples collected within a 30-day period. In addition, monitoring frequency and spatial distribution (location) of the sites should match those of high vulnerability points. For instance, July, August and September should have more sampling conducted due to the critical condition of low flow. The months of May, June, and October generally have higher flows due to rainfall events and greater dilution factors. Data collected during the period extending from June 1st through October 31st (minimum of 20 samples at key sites) should be used to calculate the geometric mean and to evaluate the stream for the current year.

The USGS is under contract with the department to perform annual monitoring just upstream of the mouth of the Jacks Fork River. They sample six times per year for a variety of parameters, including fecal coliform, fecal streptococci and *E. coli*. This is a long term monitoring site.

The current water-quality study of the Jacks Fork, which was funded through the USGS/NPS Water-Quality Partnership Program, was designed to be completed in three phases. Phase I was conducted from March -August 1999, Phase II from November 1999-December 2000 and Phase III was begun in January 2001. Phase III will continue indefinitely as long as funding is available. The purpose of Phase III was to establish sampling locations for routine long-term water-quality monitoring. USGS has sampled at 10 locations from January 2001 through October 2002 and May through October 2003 as part of Phase III of the study. Part of the work done in 2003 was hourly fecal coliform/*E. coli* sampling at a location on the Jacks Fork just above Lick Log Hollow. This was done twice during a busy camping/canoe weekend and during the August and October trail rides.

Another USGS/NPS Water-Quality Partnership Project has been funded to look at the role of streambed sediments in the bacteria concentrations. The streambed-sediment study also includes collecting bacteria samples from the water column. This part of the study began in the spring of 2003 and should continue through September 30, 2005. In addition, USGS is doing streambed sediment sampling and some rep-PCR (see footnote 7, page 3) sampling at nine of the 10 long-term monitoring sites. Although there is no sediment to sample at the Eminence WWTF and previous data indicated the plant was meeting their permit limit, USGS has continued to collect a water sample from the WWTF for bacteria analysis during every sampling event. Finally, the NPS has provided funding for FY 2004 to do additional rep-PCR work to try and better identify the sources of the bacteria. This will include sampling of the water column and the streambed sediments. The current Phase III and streambed sediment sampling being conducted by USGS continues to characterize the fecal coliform problem. It is important to continue water quality monitoring, particularly when changes are made that could have an effect on the fecal coliform densities in the Jacks Fork.

Effluent monitoring frequencies, as specified in the individual permits, will not be affected by this TMDL. DMR data from Eminence and Mountain View indicates the fecal coliform limit of 200 col/100 mL has been exceeded less than four percent of the time over the last five years.

9. IMPLEMENTATION

The utility of a load duration curve is that it points out the sources of the pollutant. High fecal coliform numbers at base (low) flow, for example, indicate point source problems. This is because there is no runoff from rain events occurring during base flow and, therefore, there is no contribution occurring from runoff and nonpoint sources. At storm flows, on the other hand, rain events result in considerable runoff from nonpoint sources. So, high bacteria numbers during medium or high flow events indicates nonpoint sources are the major concern and better watershed management is required. It should be noted that it is documented that the two point sources in the watershed are discharging high quality effluent (Section 8 above). Therefore, the exceedences of the geometric mean on the Jacks Fork at extreme low flows are likely caused by other sources that act like point sources. These sources, sometimes referred to as direct nonpoint sources, include leaking septic systems and animals defecating directly in the river.

To stay below the TMDL load curve, existing loading of bacteria must be reduced. Improved watershed management will reduce fecal coliform contamination and improve water quality in multiple ways by reducing sediment and nutrient inputs. Efforts should try to address all sources of bacteria. Possibilities include limiting livestock access to the river, providing more public toilets on the river, addressing septic tank maintenance issues in the watershed, reducing the time horses spend in the river at crossings and improving animal manure management.

On May 15, 2003, Cross Country Trail Rides (CCTR) entered into a Settlement Agreement (SA) with the department. The major concern addressed by this agreement is manure management at the facility. CCTR agreed to develop and implement a Stormwater Improvement Plan by no later than April 15, 2004. The plan was developed, approved and signed by the department August 29, 2003, well ahead of the September 30 deadline for plan development. The components of this plan “ensure proper onsite waste handling and reduce the risk of discharge of contaminated stormwater to the Jacks Fork River.” The Stormwater Improvement Engineering Report was submitted October 24, 2003, four days ahead of schedule. Implementation of the Plan is underway. CCTR also agreed in the SA to work with the department in setting a reasonable schedule for the facility to connect to the Eminence Wastewater Treatment Facility for treatment of human waste generated by trail ride participants. Since 1979, CCTR has captured and contained all wastewater generated by trail ride participants and has paid to have it transported to the Eminence WWTF. They are now working to install system upgrades to allow them to pump wastewater directly to the WWTF to facilitate the process.

In April 2003, the department started a series of public meetings for interested stakeholders. Initially, these meetings informed residents of the results of water quality studies, explained TMDLs and supported the formation of a watershed partnership for local decision making. The *Jacks Fork Watershed Committee* has been established as a result. The group consists of approximately 30 local stakeholders. The long-term goal is to develop a comprehensive watershed management plan. The following is their mission statement:

To educate, preserve, protect and promote water quality and recreational use of the Jacks Fork River and its watershed.

Participants in the watershed committee represent a wide range of interests. The group has decided that designated residents of the watershed will be the voting members for decision making and all other participants will serve in an advisory capacity. Represented interests include:

- Canoe Liveries
- Campground Owners
- Trail Ride Representatives
- Motel and Business Owners
- Agricultural Interests (Soil & Water Conservation District)
- Stream Teams
- Environmental Organizations
- Environmental Consultants
- Local Government and Municipal Representatives
- State and Federal Agencies

The following is a summary of the suggestions for resolving the bacteria impairment, concerns related to some options and courses of action that will be pursued in the near future.

- Sanitary Facilities for Recreational Users
 - The NPS has eight public facilities along approximately 21 miles of the upper reach of the Jacks Fork within the park boundaries. On the lower reach, there are two public bathrooms within the park boundaries.
 - There is a gap, approximately four miles long, between the upper and lower sections of the park with no bathroom facilities. There are private campgrounds with facilities in this gap, but they might not be willing to provide toilet facilities for the public. The Missouri Department of Conservation (MDC) has been contacted about the possibility of providing another public bathroom on their land in this stretch of the river. One possible site is in MDC's Buttin Rock Access on the north edge of Eminence near the Hwy 19 bridge. This location would serve more users than one constructed downstream in a remote situation.
 - A major issue with providing toilet facilities is finding sites with road access for pump out trucks and other maintenance vehicles.
 - Toilet facilities must be located out of the river's floodplain to avoid damage during flood events, but close enough to the water that the public will use them.
 - Better signage of existing facilities could prove helpful. A concern is the destruction of signage during floods and the cost of replacing them.
- Recreational Use/Carrying Capacity Study
 - The NPS does routine studies on park usage and the last study done on the Jacks Fork is several years old. The NPS will consider repeating a recreational use study in the near future, as funding allows.
 - A study containing current information could provide useful insights into recreational use impacts in the Jacks Fork watershed.
- Trail Management Practices
 - Trail riders established the existing trail system around the Jacks Fork and some trails are susceptible to erosion. The Missouri Department of Conservation (MDC) has developed an approach to address the environmental impacts of the trail system on their property. Initial budget requests will begin the implementation process of trail repair and renovation. Due to the magnitude of the work at hand and the budget dollars required, it is anticipated it will take three to five years to complete the entire project. In addition, a monitoring and evaluation project has been developed to better ascertain the amount and type of horse use occurring in the area. This project will determine carrying capacity of the trail system, identify actions of cooperating agencies and identify possible partners in trail construction and maintenance.
 - Information on environmentally sound trail management is available on the web and the website information has been provided to watershed committee participants.
- Public Education Efforts
 - Develop and publish information about water quality issues and actions that recreational users can take to protect the Jacks Fork. The information should target all visitors, including canoeists, campers and trail riders. The Jacks Fork Watershed Committee has chosen to pursue development of a publication regarding "river etiquette." This information will address toileting when on or near the river, littering issues, appropriate behavior, etc.

- Development of information and/or displays regarding on-site septic systems with watershed residents as the target audience. This will be the focus of an initial effort being undertaken by the Jacks Fork Watershed Committee. An Education Committee has been established to pursue development and dissemination of information to local residents.
 - The NPS has proposed putting up kiosks (educational panels) at canoe concessions, horse outfitters, park staging areas, launch facilities, trail crossings, etc. The kiosks would have information about river etiquette and behavior, getting horses across the river as quickly as possible, map of the locations of public bathrooms, etc.
 - Potential funding sources for these efforts include the National Park Service and 319 grants. The watershed committee is partnering with the local Resource Conservation District as the funding mechanism through which they can receive grant funding.
- Repeat and/or expand rep-PCR study to determine sources of the bacteria
 - The USGS has been funded to do additional rep-PCR work during the 2004 recreational season.
 - Provision of hardened crossings for horses

This suggestion has several issues that would have to be addressed prior to implementation. These include:

 - Horses do not easily cross bridges and the bridge construction itself could cause problems in the river.
 - Gravel or concrete crossings may cause horses to slip.
 - Gravel or concrete crossings could alter the flow of water and the physical properties of the river if not done properly.
 - A gravel crossing could wash out during flood events.
 - Evaluate impact of Septic Systems
 - Would require the commitment from local residents to carry out the study.
 - Could be done by canvassing home owners.
 - Could also be done using an indicator parameter like conductivity, but would require local volunteers to collect the data.
 - Best Management Practices (BMPs) for Agriculture interests
 - Work with Natural Resource Conservation Service to evaluate what practices have already been installed and the extent of BMPs already in place in the watershed.
 - Natural Resource Conservation Service funding would be a major resource for installation of Best Management Practices.
 - Agriculture has not been identified as a significant source of the bacteria, but all assistance with water quality concerns will provide a benefit for the river.
 - Soil & Water District and local cattlemen have been willing to address these issues in the past and could just maximize existing efforts.

All Missouri TMDLs are phased. If future data collection indicates that water quality standards are not being met, this TMDL will be re-opened and/or re-evaluated. The watershed committee will be apprised of new data and encouraged to revise the watershed management plan to include additional measures if necessary.

10. REASONABLE ASSURANCES

An educated and functional stakeholder group has the knowledge and ability to affect change in a watershed. The Jacks Fork Watershed Committee will formulate plans to reduce the bacteria load in the river. Part of the function of such a group is securing the funds to enable solutions to be implemented. Possible sources of funds include:

- 319 Nonpoint Source Grants and minigrants
- Soil and Water Grants
- Farm Bill Environmental Quality Incentive Program (EQIP) Funds
- Federal Agency funding (USGS, NPS)
- Private Contributions (Equine Council, American Canoe Association, Fishing Organizations, etc.)
- State Revolving Funds for Nonpoint Sources (specifically for on-site septic financial assistance)
- Community Development Block Grants
- EPA Environmental Justice Grants
- Department of Economic Development Funds
- Missouri Department of Transportation Funds

The Settlement Agreement between CCTR and the department provides the legal authority to ensure that the terms of the agreement are met. Likewise, the department has the legal authority to enforce permit limits at facilities that have State Operating Permits.

11. PUBLIC PARTICIPATION

This water quality limited segment is included on the approved 1998 303(d) list for Missouri. Public meetings were held around the state and a public comment period was provided to give citizen's input into the 303(d) list. The Missouri Department of Natural Resources, Water Pollution Control Program, developed this TMDL.

Three public meetings have been held in Eminence, Shannon County, to get public input and ownership of plans for protecting the quality of water in the Jacks Fork. These were held on April 10, May 29 and July 10, 2003. As a result, a watershed partnership was formed (Section 9) which intends to implements several strategies for reducing the bacteria to the river. This group is holding monthly meetings in Eminence.

This TMDL document was sent to EPA for examination and then the edited draft placed on public notice from October 24, 2003 to November 23, 2003. Groups that received the public notice announcement included:

- Jacks Fork Watershed Committee
- The Missouri Clean Water Commission
- The Water Quality Coordinating Committee
- The TMDL Policy Advisory Committee
- Stream Team volunteers in the watershed (46)
- Appropriate legislators (2)
- Others that routinely receive the public notice of Missouri State Operating Permits

Any comments received during the public notice period were incorporated into the TMDL as appropriate. A copy of the notice, the comments received and the department responses may be found in the Jacks Fork River file.

12. APPENDICES AND LIST OF DOCUMENTS ON FILE WITH THE DEPARTMENT

- Appendix A – Land Use Types for the Jacks Fork River Watershed
- Appendix B – Conversion Factor and Geometric Mean Calculation
- Appendix C – Map of Sample Locations and Impaired Stream Segment
- Appendix D – Data
- Appendix E – Load Duration Curves

Documents on File

- Permits for Mountain View and Eminence WWTPs
- Permits for the four no-discharge facilities
- Settlement Agreement with CCTR and related documents
- Water Quality Investigation of the Jacks Fork River, Shannon and Texas, [DNR] Stream Survey
Sampling Report, May – November 1998
- USGS Study (1999-2000), Phase I and Phase II (See References)

REFERENCES

Allgood, F.P., I.D. Persinger, and Soil Scientists with the Soil Conservation Service. 1979. Missouri General Soil Map and Soil Association Descriptions. United States Department of Agriculture, Soil Conservation Service State Office, Columbia, Missouri.

Davis, J.V. and J.M.Richards. 2001. Assessment of Microbiological Contamination of the Jacks Fork within the Ozark National Scenic Riverways, Missouri – Phase I. USGS Fact Sheet 026-01 US Geological Survey, Rolla, Missouri.

Davis, J.V. and J.M.Richards. 2002. Assessment of Possible Sources of Microbiological Contamination and Water-Quality Characteristics of the Jacks Fork within the Ozark National Scenic Riverways, Missouri – Phase II. United States Geological Survey Water-Resources Investigations Report 02-4209. US Geological Survey, Rolla, Missouri.

Jacobson, R.B. and A.T. Primm. 1994. Historical land-use changes and potential effects of stream disturbance in Ozark Plateaus, Missouri. United States Geologic Survey Open File Report 94-333. US Geological Survey, Rolla, Missouri.

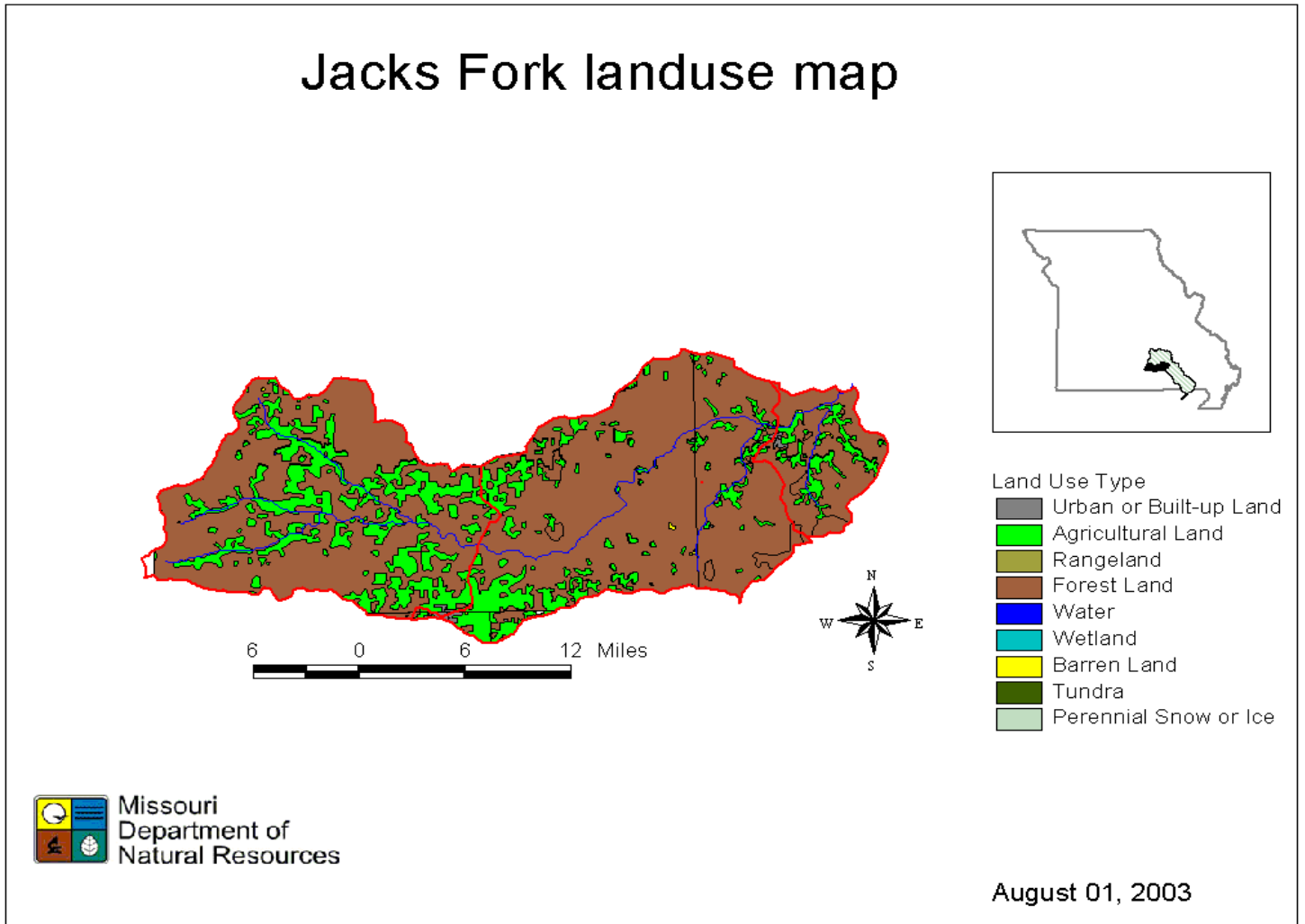
Missouri Department of Natural Resources, Water Quality Standards, 10 CSR 20-7.031.
<http://www.sos.mo.gov/adrules/csr/current/10csr/10c20-7a.pdf>

U.S. Environmental Protection Agency. 2001. *Protocol for Developing Pathogen TMDLs*. EPA 841-R-00-002. Office of Water (4503F), United States Environmental Protection Agency, Washington, DC.
http://www.epa.gov/owow/tmdl/pathogen_all.pdf

USGS, Flood-frequency analysis
ftp://water.usgs.gov/pub/software/surface_water/peakfq/doc/peakfq.pdf

Appendix A

Spatial Distribution Map of Land Use in Jacks Fork River Watershed



Detailed land use	Distribution
Sub-Watershed	Total Area
=====	=====
Land Use Name and Code	(acres)
-----	-----
Urban or Built-up Land	
RESIDENTIAL-11	653
COMMERCIAL AND SERVICES-12	286
INDUSTRIAL-13	47
TRANS, COMM, UTIL-14	11
MXD URBAN OR BUILT-UP-16	135
OTHER URBAN OR BUILT-UP-17	19
Subtotal	1151
 Agricultural Land	
CROPLAND AND PASTURE-21	57425
OTHER AGRICULTURAL LAND-24	62
Subtotal	57487
 Forest Land	
DECIDUOUS FOREST LAND-41	219398
EVERGREEN FOREST LAND-42	462
MIXED FOREST LAND-43	4682
Subtotal	224542
 Water	
RESERVOIRS-53	23
Subtotal	23
 Barren Land	
SANDY AREA (NON-BEACH)-73	19
TRANSITIONAL AREAS-76	180
Subtotal	199
 Unclassified	
	0 62
Subtotal	62
=====	=====
Total	283464

Appendix B

Conversion factor determination:

(Number of col/100 mL) x (Flow ft³/s) x (conversion factor) = Number of colonies per day.
Where (28316.84659 mL/ft³) x (86400 s/day) / 100 = 24465755.45 is the conversion factor.

ft³/s (or cfs) = cubic feet per second

Geometric mean (GM) calculation:

The geometric mean of n (some number) samples $y_1, y_2, y_3, \dots, y_n$, is the n^{th} root of their product.

That is: $GM = (y_1 * y_2 * y_3 * \dots * y_{n-1} * y_n)^{1/n}$
* = times or multiplied by

This is equivalent to

$$\text{EXP}(\ln GM) = \text{EXP}\{(1/n) * (\ln y_1 + \ln y_2 + \dots + \ln y_n)\}$$

Where

EXP returns the e raised to the power of ln GM.

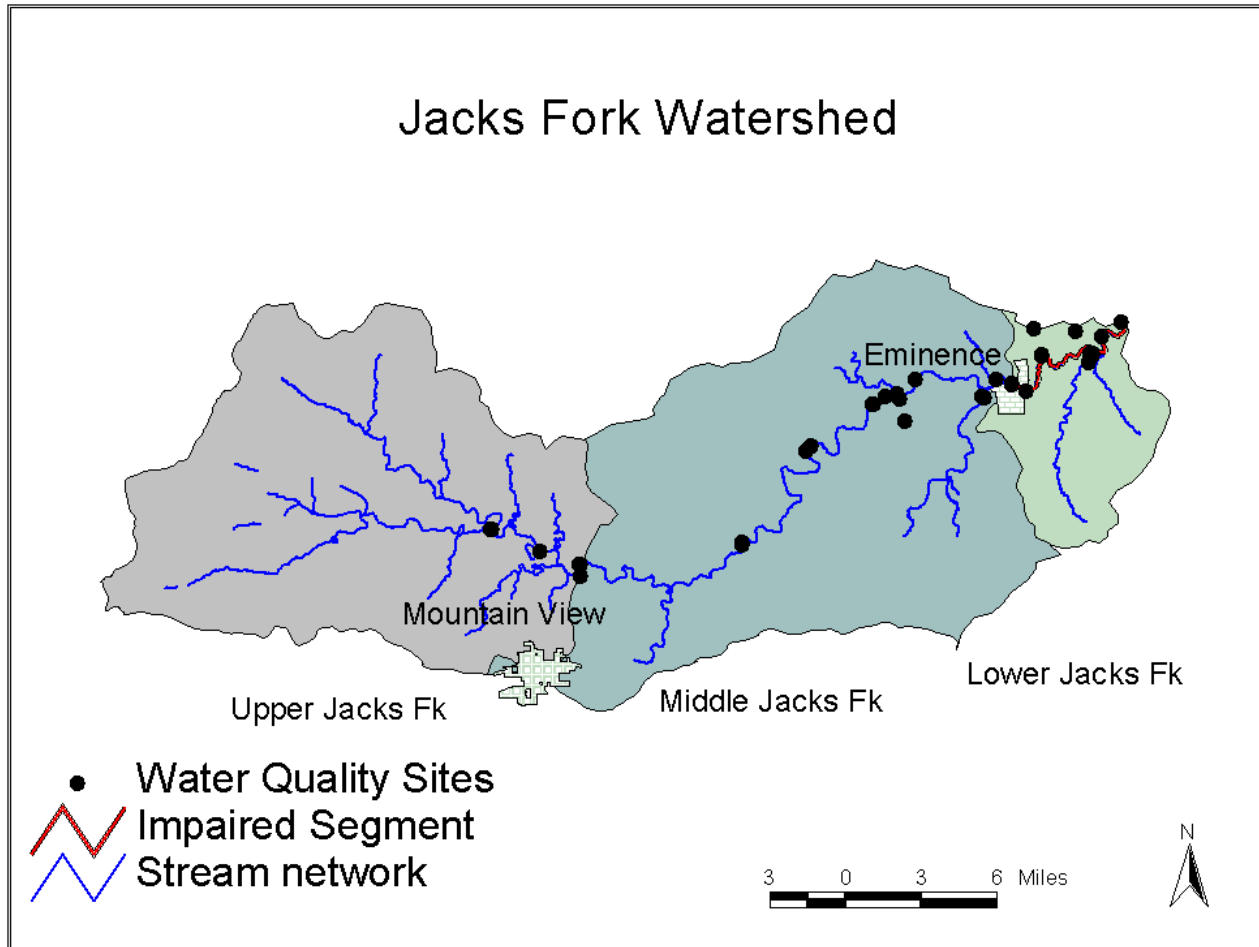
“e” is the base of the natural logarithm ($e = 2.7182818$).

“ln” is the natural logarithm

GM is the geometric mean.

Appendix C

Figure 1. Map of Jacks Fork River Watershed with Sampling Sites and Impaired Portion



Appendix C (continued)

Table 1. Sampling Sites on Jacks Fork River Watershed and its Tributaries

Site	Site Name	Legal Description	Cross Reference Site #
2681/0.2	Jacks Fork at Two Rivers	NW NE Sec.16,29N,3W	USGS 07066110
2681/1.3	Jacks Fk. bl. L. Shawnee Cr.	NW SE Sec.17,25,3W	
2681/1.9	Jacks Fk. ab. L. Shawnee Cr.	NW NE Sec.20, 25,3W	
2681/11.3/0.1	Horse Hollow bl. Alley Spring	NW NW NE Sec.30,T29N,R4W	USGS 370942091252701
2681/12.2	Jacks Fk. bl. Alley Spring	SE NW SW Sec.30,T29N,R4W	USGS 370905091255401
2681/13	Jacks Fk. Above Alley Spring	SW SW Sec.25,29,5W	USGS 370857091265901
2681/13.0	Jacks Fk. at Hwy 106	SW SW SE Sec.25,T29N,R5W	NPS-ONSR Site OZAR0066
2681/18.4	Jacks Fk. at Bay Creek	SW SW Sec.4,28N,5W	NPS-ONSR Site OZAR0082
2681/18.4/0.1	Bay Creek near Mouth	SW SW Sec.4T28N,R5W	NPS-ONSR Site OZAR0083
2681/2.2	Jacks Fk. bl. Shawnee Cr.	SW NE NW Sec.20,T29N,R3W	NPS-ONSR Site OZAR0036
2681/2.3	Jacks Fk. ab. Shawnee Cr.	SW NE NW Sec.20,T29N,R3W	NPS-ONSR Site OZAR0038
2681/2.5	Jacks Fk. above Two Rivers	NE NW Sec.20,T29N,R3W	USGS 07066110
2681/2.7	Jacks Fk. ab. Powell Spring	NE NE Sec.19,29,3W	USGS 371026091183301
2681/28	Jacks Fk. at Rymer Spring	NE SE NE Sec.35,T28N,R6W	NPS-ONSR Site OZAR0113
2681/3.4	Jacks Fk. ab. Bald Knob Hollow	SE NW Sec.19,25,3W	USGS 371012091191301
2681/34.4	Jacks Fk. at Blue Spring	NE NE SE Sec.31,T28N,R6W	NPS-ONSR Site OZAR0112
2681/37.2	Jacks Fk. at Hwy 17	NW NE SW Sec.36,T28N,R7W	NPS-ONSR Site OZAR0098
2681/38.1	Jacks Fk. at Hwy.17	SE SE NW Sec.36,T28N,R7W	
2681/4.3	Jacks Fk. bl. Lick Log Hollow	SW SW NW Sec.24,T29N,R4W	
2681/4.5	Jacks Fk. ab. Lick Log Hollow	SE SE NW Sec.24,25,4W	USGS 371014091201301 & NPS-ONSR Site OZAR0044
2681/6.0	Jacks Fk. bl. Cross Country T.R.	NE NE SE Sec.26,25,4W	USGS 370905091204001
2681/6.4	Jacks Fk. bl. Eminence WWTP	SW NE SE Sec.26,T29N,R4W	USGS 370907091210801
2681/6.4/0.1	Eminence WWTP outfall	NW SE Sec.26,25,4W	
2681/6.6	Jacks Fk. In Eminence at Hwy 19	NE NW SW Sec.26,T29N,R4W	USGS 07066000 & NPS-ONSR Site OZAR0047
2681/6.8	Jacks Fk. bl. Circle B Campground	NW NW SW Sec.26,T29N,R4W	
2681/7.1	Jacks Fk. bl. Story Cr.	SE NE Sec.27,T29N,R4W	USGS 370921091215001 & NPS-ONSR Site OZAR0046
2681/7.4	Jacks Fk. ab. Circle B Campground	SW SW SE Sec.27,T29N,R4W	
2681/8	Jacks Fk. bl. Mahans Cr.	NE SW Sec.27,T29N,R4W	USGS 370912091222501
2681/8.2	Jacks Fk. ab. Mahans Cr.	SE NW SW Sec.27,T29N,R4W	USGS 370910091223801

bl. = below or downstream of; ab. = above or upstream of

Appendix D

Table 1: Number of Samples Collected in the Target Area During the Recreation Season

a. Grouped by Organization

Organization	Year	Number Of Samples
MDHSS	1994	54
MDNR	1998	65
MDNR	1999	1
NPS-ONSR	1998	60
NPS-ONSR	1999	50
NPS-ONSR	2000	69
NPS-ONSR	2001	96
USGS	1993	6
USGS	1994	6
USGS	1995	4
USGS	1996	2
USGS	1997	2
USGS	1999	29
USGS	2000	25
USGS	2001	36
USGS	2002	25
Total		530

b. Grouped by Year

Year	Total Samples Per Year
1993	6
1994	60
1995	4
1996	2
1997	2
1998	125
1999	80
2000	94
2001	132
2002	25
Total	530

Table 2. Organizations with Sampling Data in Jacks Fork River Watershed

Organization Abbreviation	Organization Name
MDHSS	Missouri Department of Health and Senior Services
MDNR	Missouri Department of Natural Resources
NPS-ONSR	National Park Service-Ozark National Scenic Riverways
USGS	United States Geological Survey

Table 3: Raw Data Used to Derive Bacteria Target

This table includes the raw data only.

Site Name	Date	Flow ft ³ /s	Fecal Coliform
Jacks Fk. Above Alley Spring	4/20/1993	539	1
Jacks Fk. Above Alley Spring	5/11/1993	524	20
Jacks Fk. Above Alley Spring	6/2/1993	136	8
Jacks Fk. Above Alley Spring	7/21/1993	91	26
Jacks Fk. Above Alley Spring	8/18/1993	79	22
Jacks Fk. Above Alley Spring	10/13/1993	212	7
Jacks Fk. In Eminence at Hwy 19	4/5/1994		40
Jacks Fk. at Hwy 106	4/5/1994		7
Jacks Fk. at Bay Creek	4/5/1994		7
Jacks Fk. at Hwy.17	4/5/1994		23
Jacks Fk. In Eminence at Hwy 19	5/25/1994		54
Jacks Fk. at Hwy 106	5/25/1994		6
Jacks Fk. at Bay Creek	5/25/1994		22
Jacks Fk. at Rymer Spring	5/25/1994		13
Jacks Fk. at Hwy.17	5/25/1994		20
Jacks Fk. Above Alley Spring	5/27/1994	222	2
Jacks Fk. In Eminence at Hwy 19	5/31/1994		750
Jacks Fk. at Hwy 106	5/31/1994		690
Jacks Fk. at Bay Creek	5/31/1994		630
Jacks Fk. at Rymer Spring	5/31/1994		55
Jacks Fk. at Hwy.17	5/31/1994		790
Jacks Fk. Above Alley Spring	6/7/1994	354	120
Jacks Fk. In Eminence at Hwy 19	6/29/1994		10
Jacks Fk. at Hwy 106	6/29/1994		20
Jacks Fk. at Rymer Spring	6/29/1994		20
Jacks Fk. at Bay Creek	6/29/1994		10
Jacks Fk. at Hwy.17	6/29/1994		9
Jacks Fk. In Eminence at Hwy 19	7/5/1994		60
Jacks Fk. at Hwy 106	7/5/1994		10
Jacks Fk. at Rymer Spring	7/5/1994		10
Jacks Fk. at Bay Creek	7/5/1994		9

Jacks Fk. at Hwy.17	7/5/1994		10
Jacks Fk. Above Alley Spring	7/19/1994	204	700
Jacks Fk. In Eminence at Hwy 19	8/3/1994		26
Jacks Fk. at Hwy 106	8/3/1994		18
Jacks Fk. at Rymer Spring	8/3/1994		27
Jacks Fk. at Bay Creek	8/3/1994		56
Jacks Fk. at Hwy.17	8/3/1994		56
Jacks Fk. Above Alley Spring	8/9/1994	112	110
Jacks Fk. In Eminence at Hwy 19	8/15/1994		7
Jacks Fk. at Hwy 106	8/15/1994		4
Jacks Fk. at Bay Creek	8/15/1994		2
Jacks Fk. at Rymer Spring	8/15/1994		18
Jacks Fk. at Hwy.17	8/15/1994		15
Jacks Fk. In Eminence at Hwy 19	8/31/1994		120
Jacks Fk. at Hwy 106	8/31/1994		10
Jacks Fk. at Rymer Spring	8/31/1994		110
Jacks Fk. at Bay Creek	8/31/1994		30
Jacks Fk. at Hwy.17	8/31/1994		440
Jacks Fk. In Eminence at Hwy 19	9/6/1994		120
Jacks Fk. at Hwy 106	9/6/1994		110
Jacks Fk. at Rymer Spring	9/6/1994		4200
Jacks Fk. at Bay Creek	9/6/1994		1300
Jacks Fk. at Hwy.17	9/6/1994		2400
Jacks Fk. Above Alley Spring	9/20/1994	77	12
Jacks Fk. In Eminence at Hwy 19	9/28/1994		31
Jacks Fk. at Hwy 106	9/28/1994		5
Jacks Fk. at Rymer Spring	9/28/1994		26
Jacks Fk. at Bay Creek	9/28/1994		6
Jacks Fk. at Hwy.17	9/28/1994		27
Jacks Fk. In Eminence at Hwy 19	10/10/1994		14
Jacks Fk. at Hwy 106	10/10/1994		13
Jacks Fk. at Rymer Spring	10/10/1994		20
Jacks Fk. at Bay Creek	10/10/1994		5
Jacks Fk. at Hwy.17	10/10/1994		34
Jacks Fk. Above Alley Spring	10/20/1994	88	22
Jacks Fk. Above Alley Spring	4/11/1995	1860	1500
Jacks Fk. Above Alley Spring	5/22/1995	295	4

Jacks Fk. Above Alley Spring	7/6/1995	210	20
Jacks Fk. Above Alley Spring	8/9/1995	124	42
Jacks Fk. Above Alley Spring	5/14/1996	716	69
Jacks Fk. Above Alley Spring	8/21/1996	95	5
Jacks Fk. Above Alley Spring	5/29/1997	190	5
Jacks Fk. Above Alley Spring	8/7/1997	71	11
Jacks Fk. In Eminence at Hwy 19	5/5/1998		12
Jacks Fk. bl. Circle B Campground	5/5/1998		17
Jacks Fk. ab. Circle B Campground	5/5/1998		17
Jacks Fk. bl. Alley Spring	5/5/1998		12
Jacks Fk. at Hwy.17	5/5/1998		8
Jacks Fk. In Eminence at Hwy 19	5/24/1998		12
Jacks Fk. bl. Circle B Campground	5/24/1998		10
Jacks Fk. ab. Circle B Campground	5/24/1998		12
Jacks Fk. bl. Alley Spring	5/24/1998		22
Jacks Fk. at Hwy.17	5/24/1998		25
Jacks Fk. at Hwy.17	5/25/1998		33
Jacks Fk. bl. Circle B Campground	5/25/1998		15
Jacks Fk. ab. Circle B Campground	5/25/1998		32
Jacks Fk. bl. Alley Spring	5/25/1998		13
Jacks Fk. at Hwy.17	5/25/1998		10
Jacks Fk. ab. Circle B Campground	5/25/1998		12
Jacks Fk. bl. Alley Spring	5/25/1998		7
Jacks Fk. In Eminence at Hwy 19	5/25/1998		105
Jacks Fk. bl. Circle B Campground	5/25/1998		135
Jacks Fk. ab. Circle B Campground	5/25/1998		137
Jacks Fk. bl. Alley Spring	5/25/1998		45
Jacks Fk. at Hwy.17	5/25/1998		28
Jacks Fk. In Eminence at Hwy 19	5/25/1998		15
Jacks Fk. bl. Circle B Campground	5/25/1998		7
Jacks Fk. In Eminence at Hwy 19	5/25/1998		53
Jacks Fk. In Eminence at Hwy 19	5/26/1998		80
Jacks Fk. bl. Circle B Campground	5/26/1998		37
Jacks Fk. ab. Circle B Campground	5/26/1998		27
Jacks Fk. bl. Alley Spring	5/26/1998		26
Jacks Fk. at Hwy.17	5/26/1998		33
Jacks Fk. In Eminence at Hwy 19	5/26/1998		17

Jacks Fk. bl. Circle B Campground	5/26/1998		10
Jacks Fk. ab. Circle B Campground	5/26/1998		23
Jacks Fk. bl. Alley Spring	5/26/1998		12
Jacks Fk. at Hwy.17	5/26/1998		22
Jacks Fk. at Hwy 106	6/2/1998		20
Jacks Fk. bl. Story Cr.	6/2/1998		8
Jacks Fk. In Eminence at Hwy 19	6/2/1998		15
Jacks Fk. at Hwy 106	6/9/1998		48
Jacks Fk. bl. Story Cr.	6/9/1998		228
Jacks Fk. In Eminence at Hwy 19	6/9/1998		230
Jacks Fk. bl. Story Cr.	6/10/1998		50
Jacks Fk. In Eminence at Hwy 19	6/10/1998		43
Jacks Fk. bl. Story Cr.	6/11/1998		42
Jacks Fk. In Eminence at Hwy 19	6/11/1998		75
Jacks Fk. at Hwy 17	6/16/1998		38
Jacks Fk. at Bay Creek	6/16/1998		30
Jacks Fk. at Blue Spring	6/16/1998		73
Jacks Fk. at Rymer Spring	6/16/1998		185
Jacks Fk. at Hwy 17	6/23/1998		30
Jacks Fk. at Bay Creek	6/23/1998		10
Jacks Fk. at Blue Spring	6/23/1998		18
Jacks Fk. at Rymer Spring	6/23/1998		20
Jacks Fk. at Hwy 106	6/30/1998		28
Jacks Fk. bl. Story Cr.	6/30/1998		43
Jacks Fk. In Eminence at Hwy 19	6/30/1998		73
Jacks Fk. at Hwy 17	7/7/1998		15
Jacks Fk. at Bay Creek	7/7/1998		10
Jacks Fk. at Blue Spring	7/7/1998		40
Jacks Fk. at Rymer Spring	7/7/1998		40
Jacks Fk. at Hwy 106	7/14/1998		15
Jacks Fk. bl. Story Cr.	7/14/1998		25
Jacks Fk. In Eminence at Hwy 19	7/14/1998		38
Jacks Fk. In Eminence at Hwy 19	7/21/1998		27
Jacks Fk. bl. Circle B Campground	7/21/1998		25
Jacks Fk. ab. Circle B Campground	7/21/1998		5
Jacks Fk. bl. Alley Spring	7/21/1998		17
Jacks Fk. at Hwy.17	7/21/1998		13

Jacks Fk. at Hwy 17	7/21/1998		23
Jacks Fk. at Blue Spring	7/21/1998		110
Jacks Fk. at Rymer Spring	7/21/1998		38
Jacks Fk. at Hwy 106	7/28/1998		133
Jacks Fk. at Hwy 17	7/28/1998		155
Jacks Fk. at Bay Creek	7/28/1998		123
Jacks Fk. at Blue Spring	7/28/1998		255
Jacks Fk. at Rymer Spring	7/28/1998		265
Jacks Fk. bl. Story Cr.	7/28/1998		118
Jacks Fk. In Eminence at Hwy 19	7/28/1998		133
Jacks Fk. at Hwy 106	8/4/1998		13
Jacks Fk. bl. Story Cr.	8/4/1998		25
Jacks Fk. In Eminence at Hwy 19	8/4/1998		20
Jacks Fk. In Eminence at Hwy 19	8/11/1998		32
Jacks Fk. bl. Circle B Campground	8/11/1998		57
Jacks Fk. ab. Circle B Campground	8/11/1998		12
Jacks Fk. bl. Alley Spring	8/11/1998		43
Jacks Fk. at Hwy.17	8/11/1998		18
Jacks Fk. at Hwy 17	8/11/1998		33
Jacks Fk. at Bay Creek	8/11/1998		38
Jacks Fk. at Blue Spring	8/11/1998		18
Jacks Fk. at Rymer Spring	8/11/1998		30
Jacks Fk. bl. Story Cr.	8/11/1998		135
Jacks Fk. In Eminence at Hwy 19	8/11/1998		158
Jacks Fk. bl. Story Cr.	8/12/1998		5500
Jacks Fk. In Eminence at Hwy 19	8/12/1998		7050
Jacks Fk. bl. Story Cr.	8/13/1998		173
Jacks Fk. In Eminence at Hwy 19	8/13/1998		237
Jacks Fk. bl. Story Cr.	8/14/1998		65
Jacks Fk. In Eminence at Hwy 19	8/14/1998		50
Jacks Fk. at Hwy 106	8/18/1998		28
Jacks Fk. bl. Story Cr.	8/18/1998		18
Jacks Fk. In Eminence at Hwy 19	8/18/1998		53
Jacks Fk. at Hwy 17	8/25/1998		28
Jacks Fk. at Bay Creek	8/25/1998		10
Jacks Fk. at Blue Spring	8/25/1998		50
Jacks Fk. at Rymer Spring	8/25/1998		33

Jacks Fk. In Eminence at Hwy 19	9/8/1998		7
Jacks Fk. bl. Circle B Campground	9/8/1998		35
Jacks Fk. ab. Circle B Campground	9/8/1998		8
Jacks Fk. bl. Alley Spring	9/8/1998		6
Jacks Fk. at Hwy.17	9/8/1998		3
Jacks Fk. In Eminence at Hwy 19	10/10/1998		45
Jacks Fk. bl. Circle B Campground	10/10/1998		63
Jacks Fk. ab. Circle B Campground	10/10/1998		70
Jacks Fk. bl. Alley Spring	10/10/1998		122
Jacks Fk. at Hwy.17	10/10/1998		5
Jacks Fk. In Eminence at Hwy 19	10/11/1998		2
Jacks Fk. bl. Circle B Campground	10/11/1998		38
Jacks Fk. ab. Circle B Campground	10/11/1998		2
Jacks Fk. bl. Alley Spring	10/11/1998		2
Jacks Fk. at Hwy.17	10/11/1998		2
Jacks Fk. In Eminence at Hwy 19	10/29/1998		13
Jacks Fk. bl. Circle B Campground	10/29/1998		9
Jacks Fk. ab. Circle B Campground	10/29/1998		15
Jacks Fk. bl. Alley Spring	10/29/1998		22
Jacks Fk. at Hwy.17	10/29/1998		9
Jacks Fk. Above Alley Spring	5/4/1999		14
Jacks Fk. bl. Alley Spring	5/4/1999	357	12
Jacks Fk. In Eminence at Hwy 19	5/4/1999		18
Horse Hollow bl. Alley Spring	5/4/1999	5.6	15
Jacks Fk. Above Alley Spring	5/10/1999	307	10
Horse Hollow bl. Alley Spring	5/10/1999	7	8
Jacks Fk. bl. Alley Spring	5/10/1999	597	88
Jacks Fk. Above Alley Spring	5/11/1999	287	21
Jacks Fk. ab. Mahans Cr.	5/11/1999	597	68
Jacks Fk. In Eminence at Hwy 19	5/11/1999	519	66
Jacks Fk. bl. Story Cr.	5/11/1999		40
Jacks Fk. at Hwy 106	6/8/1999		15
Jacks Fk. bl. Story Cr.	6/8/1999		22
Jacks Fk. In Eminence at Hwy 19	6/8/1999		10
Jacks Fk. bl. Story Cr.	6/9/1999		330
Jacks Fk. In Eminence at Hwy 19	6/9/1999		30
Jacks Fk. bl. Story Cr.	6/10/1999		680

Jacks Fk. In Eminence at Hwy 19	6/10/1999		8
Jacks Fk. bl. Story Cr.	6/11/1999		315
Jacks Fk. In Eminence at Hwy 19	6/11/1999		18
Jacks Fk. at Hwy 17	6/15/1999		18
Jacks Fk. at Blue Spring	6/15/1999		28
Jacks Fk. at Rymer Spring	6/15/1999		5
Jacks Fk. Above Alley Spring	6/22/1999	82	4
Jacks Fk. ab. Mahans Cr.	6/22/1999	217	2
Horse Hollow bl. Alley Spring	6/22/1999	1	10
Jacks Fk. bl. Alley Spring	6/22/1999	215	5
Jacks Fk. at Hwy 106	6/22/1999		10
Jacks Fk. bl. Story Cr.	6/22/1999		38
Jacks Fk. In Eminence at Hwy 19	6/22/1999		8
Jacks Fk. Above Alley Spring	6/23/1999		21
Jacks Fk. In Eminence at Hwy 19	6/23/1999	227	33
Jacks Fk. bl. Story Cr.	6/23/1999		30
Jacks Fk. Above Alley Spring	6/24/1999	107	16
Jacks Fk. In Eminence at Hwy 19	6/24/1999	243	56
Jacks Fk. at Hwy 17	6/29/1999		12
Jacks Fk. at Bay Creek	6/29/1999		5
Jacks Fk. at Blue Spring	6/29/1999		15
Jacks Fk. at Rymer Spring	6/29/1999		15
Jacks Fk. at Hwy 106	7/6/1999		25
Jacks Fk. bl. Story Cr.	7/6/1999		22
Jacks Fk. In Eminence at Hwy 19	7/6/1999		30
Jacks Fk. at Hwy 17	7/13/1999		20
Jacks Fk. at Bay Creek	7/13/1999		20
Jacks Fk. at Blue Spring	7/13/1999		10
Jacks Fk. at Rymer Spring	7/13/1999		8
Jacks Fk. at Hwy 106	7/20/1999		15
Jacks Fk. bl. Story Cr.	7/20/1999		45
Jacks Fk. In Eminence at Hwy 19	7/20/1999		18
Jacks Fk. at Hwy 17	7/27/1999		8
Jacks Fk. at Blue Spring	7/27/1999		5
Jacks Fk. at Rymer Spring	7/27/1999		8
Jacks Fk. at Hwy 106	8/3/1999		22
Jacks Fk. bl. Story Cr.	8/3/1999		18

Jacks Fk. In Eminence at Hwy 19	8/3/1999		12
Jacks Fk. Above Alley Spring	8/10/1999	61	3
Horse Hollow bl. Alley Spring	8/10/1999	0.82	10
Jacks Fk. bl. Alley Spring	8/10/1999	169	12
Jacks Fk. ab. Mahans Cr.	8/10/1999	178	16
Jacks Fk. at Hwy 17	8/10/1999		90
Jacks Fk. at Blue Spring	8/10/1999		180
Jacks Fk. bl. Story Cr.	8/10/1999		32
Jacks Fk. In Eminence at Hwy 19	8/10/1999		32
Jacks Fk. Above Alley Spring	8/11/1999		9
Jacks Fk. In Eminence at Hwy 19	8/11/1999	194	120
Jacks Fk. bl. Story Cr.	8/11/1999		40
Jacks Fk. bl. Story Cr.	8/11/1999		38
Jacks Fk. In Eminence at Hwy 19	8/11/1999		8
Jacks Fk. In Eminence at Hwy 19	8/12/1999	189	540
Jacks Fk. In Eminence at Hwy 19	8/13/1999		120
Jacks Fk. In Eminence at Hwy 19	8/16/1999		6
Jacks Fk. at Hwy 106	8/17/1999		25
Jacks Fk. bl. Story Cr.	8/17/1999		12
Jacks Fk. In Eminence at Hwy 19	8/17/1999		28
Jacks Fk. at Hwy 17	8/24/1999		15
Jacks Fk. at Blue Spring	8/24/1999		38
Jacks Fk. at Rymer Spring	8/24/1999		18
Jacks Fk. at Hwy 106	8/31/1999		10
Jacks Fk. bl. Story Cr.	8/31/1999		5
Jacks Fk. In Eminence at Hwy 19	8/31/1999		15
Jacks Fk. Above Alley Spring	4/4/2000	117	2
Jacks Fk. In Eminence at Hwy 19	4/5/2000	241	27
Jacks Fk. In Eminence at Hwy 19	5/11/2000	149	36
Jacks Fk. In Eminence at Hwy 19	5/12/2000		35
Jacks Fk. Above Alley Spring	5/23/2000	42	7
Jacks Fk. In Eminence at Hwy 19	5/24/2000	130	30
Jacks Fk. In Eminence at Hwy 19	5/24/2000		2
Jacks Fk. Above Alley Spring	5/25/2000		7
Jacks Fk. In Eminence at Hwy 19	5/25/2000		120
Bay Creek near Mouth	5/31/2000		22
Jacks Fk. at Hwy 106	5/31/2000		18

Jacks Fk. at Hwy 17	5/31/2000		5
Jacks Fk. at Bay Creek	5/31/2000		10
Jacks Fk. at Blue Spring	5/31/2000		50
Jacks Fk. at Rymer Spring	5/31/2000		32
Jacks Fk. bl. Story Cr.	5/31/2000		20
Jacks Fk. In Eminence at Hwy 19	5/31/2000		35
Jacks Fk. Above Alley Spring	6/6/2000	73	1
Jacks Fk. at Hwy 106	6/6/2000		8
Jacks Fk. bl. Story Cr.	6/6/2000		20
Jacks Fk. In Eminence at Hwy 19	6/6/2000		42
Jacks Fk. In Eminence at Hwy 19	6/7/2000	172	28
Jacks Fk. bl. Story Cr.	6/7/2000		28
Jacks Fk. In Eminence at Hwy 19	6/7/2000		30
Jacks Fk. bl. Story Cr.	6/8/2000		32
Jacks Fk. In Eminence at Hwy 19	6/8/2000		23
Jacks Fk. at Hwy 106	6/15/2000		27
Jacks Fk. bl. Story Cr.	6/15/2000		51
Jacks Fk. In Eminence at Hwy 19	6/15/2000		42
Jacks Fk. at Hwy 17	6/27/2000		26
Jacks Fk. at Bay Creek	6/27/2000		9
Jacks Fk. at Blue Spring	6/27/2000		21
Jacks Fk. at Rymer Spring	6/27/2000		22
Jacks Fk. Above Alley Spring	6/28/2000	123	13
Jacks Fk. at Hwy 106	6/28/2000		10
Jacks Fk. bl. Story Cr.	6/28/2000		62
Jacks Fk. In Eminence at Hwy 19	6/28/2000		49
Jacks Fk. In Eminence at Hwy 19	6/29/2000	245	68
Jacks Fk. bl. Story Cr.	6/29/2000		28
Jacks Fk. In Eminence at Hwy 19	6/29/2000		24
Jacks Fk. Above Alley Spring	7/10/2000	50	18
Jacks Fk. In Eminence at Hwy 19	7/11/2000	160	33
Jacks Fk. at Hwy 17	7/11/2000		23
Jacks Fk. at Bay Creek	7/11/2000		6
Jacks Fk. at Blue Spring	7/11/2000		22
Jacks Fk. at Rymer Spring	7/11/2000		26
Jacks Fk. at Hwy 106	7/12/2000		81
Jacks Fk. bl. Story Cr.	7/12/2000		105

Jacks Fk. In Eminence at Hwy 19	7/12/2000		60
Jacks Fk. at Hwy 106	7/25/2000		26
Jacks Fk. at Hwy 17	7/25/2000		36
Jacks Fk. at Bay Creek	7/25/2000		10
Jacks Fk. at Blue Spring	7/25/2000		26
Jacks Fk. at Rymer Spring	7/25/2000		24
Jacks Fk. bl. Story Cr.	7/25/2000		25
Jacks Fk. In Eminence at Hwy 19	7/25/2000		57
Jacks Fk. In Eminence at Hwy 19	7/27/2000	143	2
Jacks Fk. Above Alley Spring	7/28/2000	44	7
Bay Creek nr. Mouth	8/8/2000		8
Jacks Fk. at Hwy 106	8/8/2000		14
Jacks Fk. at Hwy 17	8/8/2000		34
Jacks Fk. at Bay Creek	8/8/2000		6
Jacks Fk. at Blue Spring	8/8/2000		11
Jacks Fk. at Rymer Spring	8/8/2000		51
Jacks Fk. bl. Story Cr.	8/8/2000		10
Jacks Fk. In Eminence at Hwy 19	8/8/2000		40
Jacks Fk. bl. Story Cr.	8/9/2000		30
Jacks Fk. In Eminence at Hwy 19	8/9/2000		30
Jacks Fk. In Eminence at Hwy 19	8/10/2000		25
Jacks Fk. Above Alley Spring	8/11/2000	36	24
Jacks Fk. bl. Story Cr.	8/11/2000		32
Jacks Fk. In Eminence at Hwy 19	8/11/2000		24
Jacks Fk. Above Alley Spring	8/22/2000	33	2
Jacks Fk. In Eminence at Hwy 19	8/22/2000	127	12
Bay Creek nr. Mouth	8/23/2000		3
Jacks Fk. at Hwy 17	8/23/2000		18
Jacks Fk. at Bay Creek	8/23/2000		9
Jacks Fk. at Blue Spring	8/23/2000		18
Jacks Fk. at Rymer Spring	8/23/2000		25
Jacks Fk. at Hwy 106	8/24/2000		41
Jacks Fk. bl. Story Cr.	8/24/2000		144
Jacks Fk. In Eminence at Hwy 19	8/24/2000		128
Bay Creek nr. Mouth	9/5/2000		28
Jacks Fk. at Hwy 17	9/5/2000		22
Jacks Fk. at Bay Creek	9/5/2000		24

Jacks Fk. at Blue Spring	9/5/2000		47
Jacks Fk. at Rymer Spring	9/5/2000		16
Jacks Fk. at Hwy 106	9/6/2000		80
Jacks Fk. bl. Story Cr.	9/6/2000		12
Jacks Fk. In Eminence at Hwy 19	9/6/2000		12
Jacks Fk. Above Alley Spring	9/20/2000	25	29
Jacks Fk. In Eminence at Hwy 19	9/20/2000	113	4
Jacks Fk. In Eminence at Hwy 19	10/3/2000	114	2
Jacks Fk. Above Alley Spring	10/4/2000	32	16
Jacks Fk. In Eminence at Hwy 19	4/24/2001	218	6
Jacks Fk. Above Alley Spring	4/25/2001	107	3
Bay Creek nr. Mouth	5/23/2001		6
Jacks Fk. at Hwy 17	5/23/2001		4
Jacks Fk. at Bay Creek	5/23/2001		8
Jacks Fk. at Blue Spring	5/23/2001		10
Jacks Fk. at Rymer Spring	5/23/2001		6
Jacks Fk. Above Alley Spring	5/25/2001	102	1
Jacks Fk. In Eminence at Hwy 19	5/25/2001	215	26
Jacks Fk. Above Alley Spring	5/26/2001	94	14
Jacks Fk. Above Alley Spring	5/26/2001	94	43
Jacks Fk. In Eminence at Hwy 19	5/26/2001	202	35
Jacks Fk. In Eminence at Hwy 19	5/26/2001	202	13
Jacks Fk. Above Alley Spring	5/27/2001	85	13
Jacks Fk. Above Alley Spring	5/27/2001	85	3
Jacks Fk. In Eminence at Hwy 19	5/27/2001	190	44
Jacks Fk. In Eminence at Hwy 19	5/27/2001	186	9
Bay Creek nr. Mouth	6/5/2001		22
Jacks Fk. at Hwy 106	6/5/2001		16
Jacks Fk. at Hwy 17	6/5/2001		22
Jacks Fk. at Bay Creek	6/5/2001		10
Jacks Fk. at Blue Spring	6/5/2001		18
Jacks Fk. at Rymer Spring	6/5/2001		2
Jacks Fk. bl. Story Cr.	6/5/2001		26
Jacks Fk. In Eminence at Hwy 19	6/5/2001		40
Jacks Fk. at Hwy 106	6/6/2001		18
Jacks Fk. bl. Story Cr.	6/6/2001		32
Jacks Fk. In Eminence at Hwy 19	6/6/2001		100

Jacks Fk. In Eminence at Hwy 19	6/6/2001	211	7
Jacks Fk. at Hwy 106	6/7/2001		6
Jacks Fk. bl. Story Cr.	6/7/2001		32
Jacks Fk. In Eminence at Hwy 19	6/7/2001		40
Jacks Fk. Above Alley Spring	6/7/2001	94	6
Bay Creek nr. Mouth	6/19/2001		10
Jacks Fk. at Hwy 106	6/19/2001		8
Jacks Fk. at Hwy 17	6/19/2001		14
Jacks Fk. at Bay Creek	6/19/2001		2
Jacks Fk. at Blue Spring	6/19/2001		38
Jacks Fk. at Rymer Spring	6/19/2001		14
Jacks Fk. bl. Story Cr.	6/19/2001		26
Jacks Fk. In Eminence at Hwy 19	6/19/2001		10
Bay Creek nr. Mouth	7/2/2001		40
Jacks Fk. at Hwy 17	7/2/2001		16
Jacks Fk. at Bay Creek	7/2/2001		22
Jacks Fk. at Blue Spring	7/2/2001		20
Jacks Fk. at Rymer Spring	7/2/2001		42
Jacks Fk. at Hwy 106	7/3/2001		20
Jacks Fk. bl. Story Cr.	7/3/2001		16
Jacks Fk. In Eminence at Hwy 19	7/3/2001		14
Jacks Fk. bl. Story Cr.	7/4/2001		14
Jacks Fk. In Eminence at Hwy 19	7/4/2001		14
Jacks Fk. at Hwy 106	7/5/2001		26
Jacks Fk. bl. Story Cr.	7/5/2001		6
Jacks Fk. In Eminence at Hwy 19	7/5/2001		30
Jacks Fk. at Rymer Spring	7/7/2001		6
Jacks Fk. at Rymer Spring	7/12/2001		164
Bay Creek nr. Mouth	7/18/2001		6
Jacks Fk. at Hwy 106	7/18/2001		12
Jacks Fk. at Hwy 17	7/18/2001		24
Jacks Fk. at Bay Creek	7/18/2001		6
Jacks Fk. at Blue Spring	7/18/2001		72
Jacks Fk. at Rymer Spring	7/18/2001		26
Jacks Fk. bl. Story Cr.	7/18/2001		70
Jacks Fk. In Eminence at Hwy 19	7/18/2001		70
Jacks Fk. at Rymer Spring	7/24/2001		129

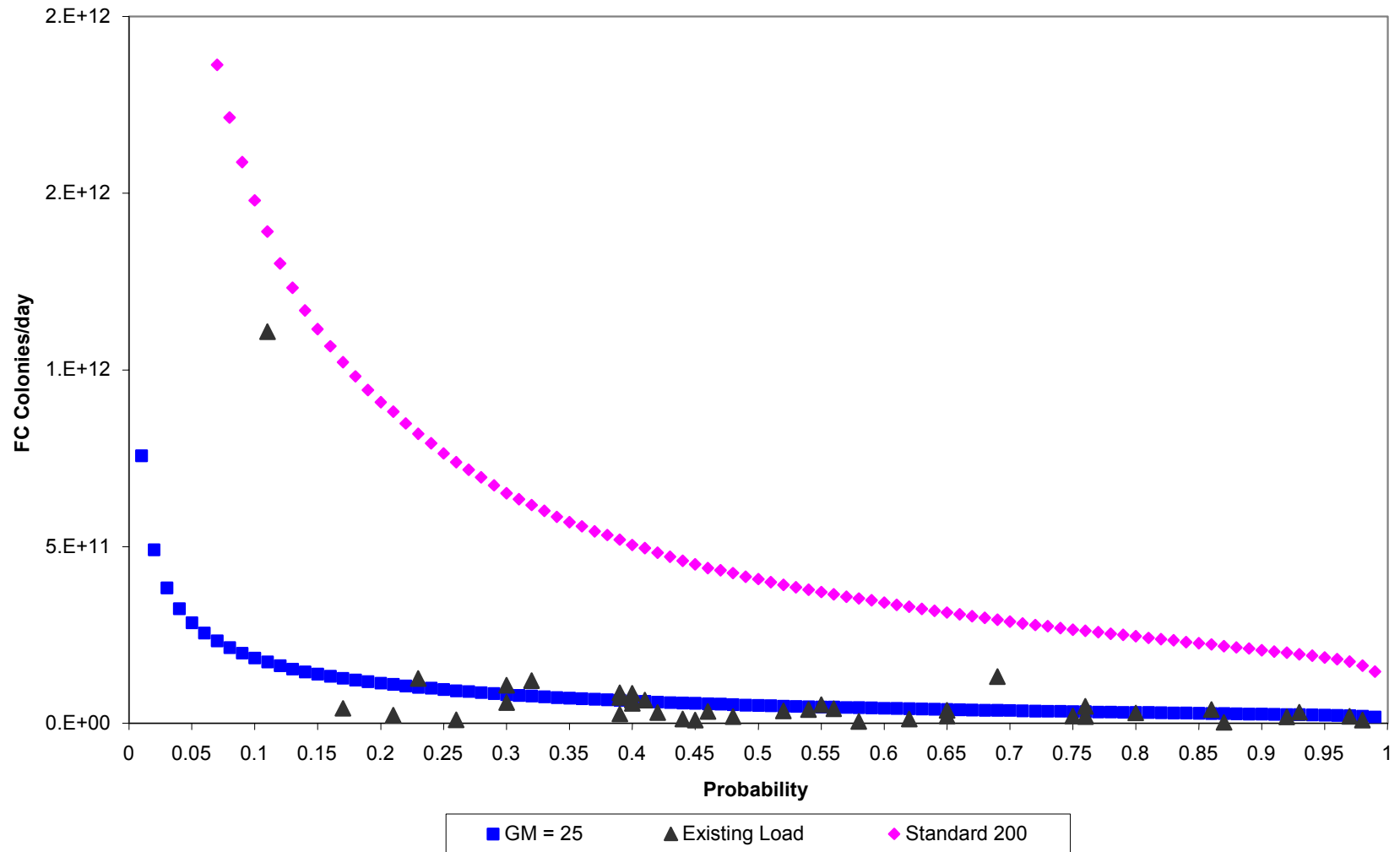
Jacks Fk. at Rymer Spring	7/26/2001		21
Jacks Fk. at Rymer Spring	7/28/2001		10
Jacks Fk. In Eminence at Hwy 19	7/28/2001		132
Jacks Fk. In Eminence at Hwy 19	7/29/2001		160
Jacks Fk. at Hwy 106	7/30/2001		30
Jacks Fk. bl. Story Cr.	7/30/2001		86
Jacks Fk. In Eminence at Hwy 19	7/30/2001		72
Jacks Fk. at Rymer Spring	7/31/2001		1
Jacks Fk. In Eminence at Hwy 19	7/31/2001	136	43
Bay Creek nr. Mouth	8/1/2001		22
Jacks Fk. at Hwy 17	8/1/2001		2
Jacks Fk. at Bay Creek	8/1/2001		12
Jacks Fk. at Blue Spring	8/1/2001		22
Jacks Fk. at Rymer Spring	8/1/2001		30
Jacks Fk. Above Alley Spring	8/1/2001	45	27
Jacks Fk. at Rymer Spring	8/2/2001		15
Jacks Fk. at Hwy 106	8/7/2001		20
Jacks Fk. at Rymer Spring	8/7/2001		1
Jacks Fk. bl. Story Cr.	8/7/2001		64
Jacks Fk. In Eminence at Hwy 19	8/7/2001		36
Jacks Fk. at Hwy 106	8/8/2001		22
Jacks Fk. bl. Story Cr.	8/8/2001		34
Jacks Fk. In Eminence at Hwy 19	8/8/2001		44
Jacks Fk. Above Alley Spring	8/8/2001	30	22
Jacks Fk. Above Alley Spring	8/8/2001	33	200
Jacks Fk. In Eminence at Hwy 19	8/8/2001	112	15
Jacks Fk. In Eminence at Hwy 19	8/8/2001	112	120
Jacks Fk. at Hwy 106	8/9/2001		22
Jacks Fk. bl. Story Cr.	8/9/2001		50
Jacks Fk. In Eminence at Hwy 19	8/9/2001		48
Jacks Fk. Above Alley Spring	8/9/2001	33	67
Jacks Fk. Above Alley Spring	8/9/2001	33	18
Jacks Fk. In Eminence at Hwy 19	8/9/2001	116	19
Jacks Fk. In Eminence at Hwy 19	8/9/2001	116	29
Jacks Fk. at Hwy 106	8/10/2001		94
Jacks Fk. bl. Story Cr.	8/10/2001		245
Jacks Fk. In Eminence at Hwy 19	8/10/2001		130

Bay Creek nr. Mouth	8/14/2001		48
Jacks Fk. at Hwy 17	8/14/2001		32
Jacks Fk. at Bay Creek	8/14/2001		8
Jacks Fk. at Blue Spring	8/14/2001		18
Jacks Fk. at Rymer Spring	8/14/2001		20
Jacks Fk. at Hwy 106	8/15/2001		16
Jacks Fk. bl. Story Cr.	8/15/2001		14
Jacks Fk. In Eminence at Hwy 19	8/15/2001		22
Jacks Fk. at Rymer Spring	8/21/2001		3
Jacks Fk. at Rymer Spring	8/28/2001		8
Bay Creek nr. Mouth	8/29/2001		56
Jacks Fk. at Hwy 17	8/29/2001		10
Jacks Fk. at Bay Creek	8/29/2001		22
Jacks Fk. at Blue Spring	8/29/2001		34
Jacks Fk. at Rymer Spring	8/29/2001		54
Jacks Fk. at Hwy 106	8/30/2001		56
Jacks Fk. bl. Story Cr.	8/30/2001		14
Jacks Fk. In Eminence at Hwy 19	8/30/2001		20
Jacks Fk. Above Alley Spring	9/18/2001	30	26
Jacks Fk. In Eminence at Hwy 19	9/18/2001	112	33
Jacks Fk. Above Alley Spring	10/2/2001	29	9
Jacks Fk. In Eminence at Hwy 19	10/2/2001	104	12
Jacks Fk. Above Alley Spring	10/10/2001	33	66
Jacks Fk. Above Alley Spring	10/10/2001	32	43
Jacks Fk. In Eminence at Hwy 19	10/10/2001	109	36
Jacks Fk. In Eminence at Hwy 19	10/10/2001	109	24
Jacks Fk. Above Alley Spring	10/11/2001	40	143
Jacks Fk. Above Alley Spring	10/11/2001	42	109
Jacks Fk. In Eminence at Hwy 19	10/11/2001	116	108
Jacks Fk. In Eminence at Hwy 19	10/11/2001	116	80
Jacks Fk. In Eminence at Hwy 19	4/2/2002	590	6
Jacks Fk. Above Alley Spring	4/30/2002	382	2
Jacks Fk. In Eminence at Hwy 19	4/30/2002	760	37
Jacks Fk. Above Alley Spring	5/29/2002	303	21
Jacks Fk. In Eminence at Hwy 19	5/29/2002	657	26
Jacks Fk. Above Alley Spring	6/4/2002	201	14
Jacks Fk. In Eminence at Hwy 19	6/4/2002	488	15

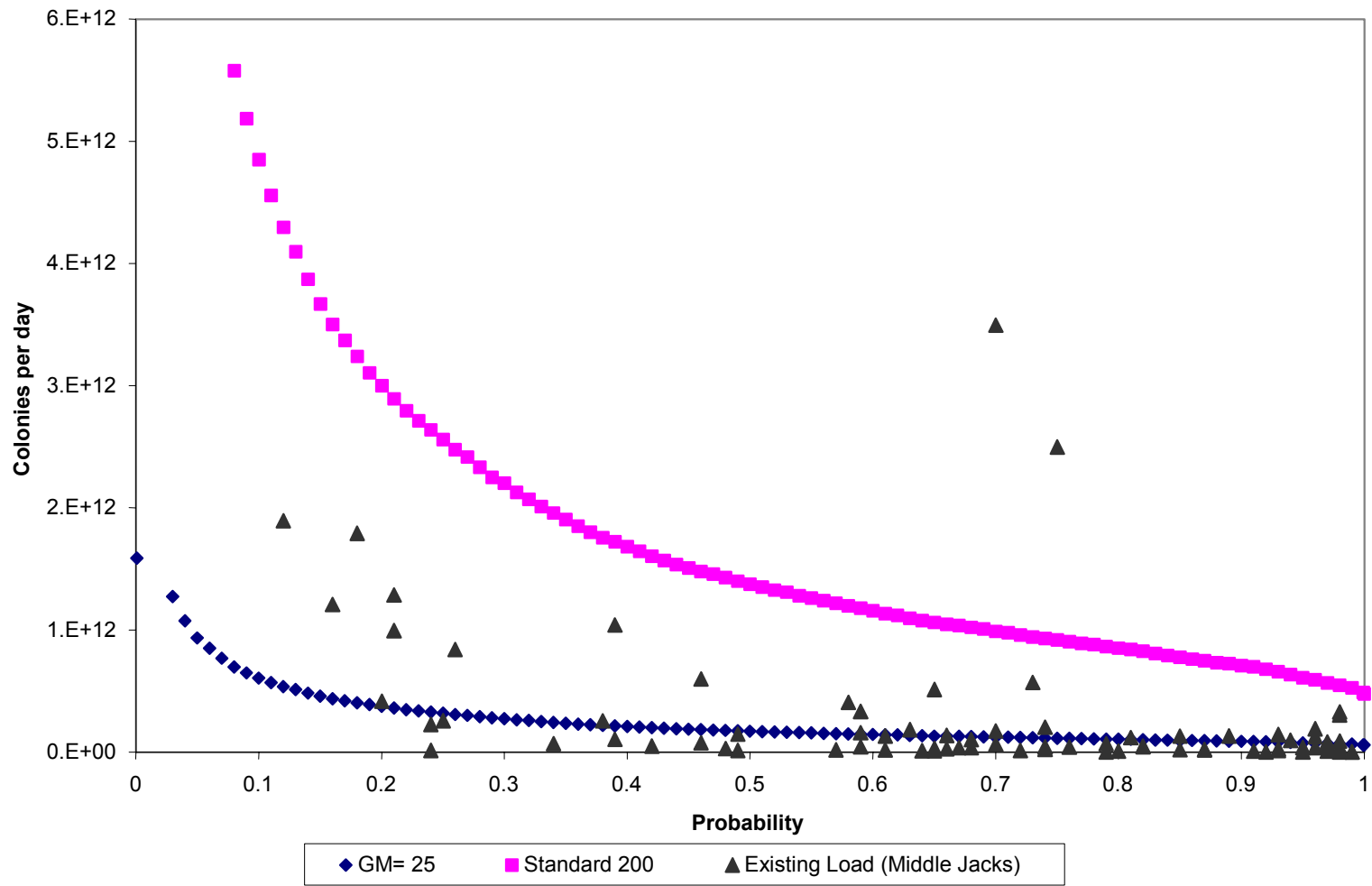
Jacks Fk. Above Alley Spring	6/28/2002	98	12
Jacks Fk. Above Alley Spring	6/28/2002	98	8
Jacks Fk. In Eminence at Hwy 19	6/28/2002	309	13
Jacks Fk. In Eminence at Hwy 19	6/28/2002	309	5
Jacks Fk. Above Alley Spring	6/29/2002	92	18
Jacks Fk. Above Alley Spring	6/29/2002	90	30
Jacks Fk. In Eminence at Hwy 19	6/29/2002	297	27
Jacks Fk. In Eminence at Hwy 19	6/29/2002	297	16
Jacks Fk. Above Alley Spring	7/29/2002	110	13
Jacks Fk. In Eminence at Hwy 19	7/29/2002	266	23
Jacks Fk. Above Alley Spring	8/6/2002	84	24
Jacks Fk. Above Alley Spring	8/6/2002	82	32
Jacks Fk. In Eminence at Hwy 19	8/6/2002	220	56
Jacks Fk. In Eminence at Hwy 19	8/6/2002	216	72
Jacks Fk. Above Alley Spring	8/7/2002	80	26
Jacks Fk. Above Alley Spring	8/7/2002	80	14
Jacks Fk. In Eminence at Hwy 19	8/7/2002	216	42
Jacks Fk. In Eminence at Hwy 19	8/7/2002	216	183

Appendix E
Load Duration (Frequency) Curves

Upper Jacks Fork Sub-watershed
Bacteria Load at Hwy 17 Bridge



Middle and Upper Sub-watersheds
Jacks Fork at Hwy 19 Bridge



**Jacks Fork at Mouth
Fecal Coliform Load for
the Whole Watershed**

